Columbian Sharp-tailed Grouse (*Tympanuchus phasianellus columbianus*): A Technical Conservation Assessment

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AUTHORS' BIOGRAPHIES

Richard W. Hoffman earned his B.Sc. and M.Sc. Degrees in wildlife biology from Colorado State University. He subsequently worked for the Colorado Division of Wildlife for over 30 years as an avian researcher specializing in upland game birds. He has conducted research on population dynamics, habitat relationships, nutritional ecology, and behavior of white-tailed ptarmigan, dusky grouse, greater prairie-chickens, Columbian sharp-tailed grouse, and wild turkey. In retirement, he continues to work on projects involving white-tailed ptarmigan, greater sage-grouse, and Columbian sharp-tailed grouse.

Allan E. Thomas earned his B.Sc. Degree in wildlife management with minors in fisheries and range management from the University of Arizona. He also conducted graduate work at the same university and received additional credits from attending schools in Washington, South Dakota, Arkansas, Alaska, and Idaho. His work experience spans more than 50 years and includes positions primarily with the Bureau of Land Management (22 years) and U.S. Fish and Wildlife Service (19 years). He retired from the Bureau of Land Management in 1999 and started another career as a private consultant in Boise, Idaho.

DEDICATION

Sadly, Allan E. Thomas passed away before this assessment was completed. Allan was a devoted conservation biologist who believed strongly in documenting and communicating biological information. This assessment is testimony to Allan's work ethic and is dedicated to his memory.

COVER PHOTO CREDIT

Photograph of male Columbian sharp-tailed grouse in an alert posture by Richard W. Hoffman.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF COLUMBIAN SHARP-TAILED GROUSE

Status

The Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*; CSTG) is one of six existing subspecies of sharp-tailed grouse in North America. It is endemic to big sagebrush (*Artemisia tridentata*), shrubsteppe, mountain shrub, and riparian shrub plant communities of western North America. The subspecies currently occupies less than 10 percent of its historic range, with only three metapopulations remaining in central British Columbia, southeastern Idaho and northern Utah, and northwestern Colorado and south-central Wyoming. Within Region 2 of the USDA Forest Service (USFS), this grouse formerly occurred in as many as 22 counties in western Colorado and in portions of 11 counties in west-central, southwestern, and south-central Wyoming. Today, viable populations occur in only three counties in Colorado and one county in Wyoming. Attempts are being made to reintroduce CSTG to previously occupied habitats in southwestern and north-central Colorado. Approximately 68 percent of the occupied habitat in Region 2 is on private lands, and only 4 percent is on lands administered by the USFS.

The CSTG has been petitioned twice for listing under the Endangered Species Act. Under both petitions, the finding was not warranted. USFS Region 2 and the state offices of the Bureau of Land Management in Colorado and Wyoming have designated the CSTG a sensitive species. Both the Wyoming Game and Fish Department and Colorado Division of Wildlife list it as a species of special concern.

Primary Threats

Threats to CSTG are widespread across its range in Region 2, occur at all spatial scales, and transcend local, state, and regional jurisdictions. Many of the threats are inter-related and synergistic in their impacts on CSTG. Even when the threats are not related, their impacts tend to be cumulative. The primary threats are all human-related. Foremost are habitat loss and degradation caused by conversion of native habitats to pasture and croplands, overgrazing by domestic livestock, energy development, use of herbicides to control big sagebrush, alteration of natural fire regimes, invasion of exotic plants, and urban and rural expansion.

Possible loss of Conservation Reserve Program (CRP) lands is the single most important immediate threat to CSTG in Region 2 and elsewhere throughout the subspecies' range. Currently, CRP lands support 21 percent of the known active leks in Region 2, and many CRP fields provide critical nesting and brood-rearing habitats for CSTG. Nearly 70 percent of all CRP contracts within the occupied range of CSTG in Region 2 are scheduled to expire by 2010, and there are strong indications that Congress will not include provisions in the 2007 Farm Bill for their renewal. What will become of these lands if the contracts are allowed to expire is uncertain, but it is likely that their value as habitat for CSTG will diminish.

Livestock grazing is the dominant use on public and private lands within the occupied range of CSTG in Region 2. While grazing levels have declined in Region 2, grazing continues to be an issue because lands subjected to past overgrazing have not been rested and given the opportunity to recover.

Until recently, oil and gas development was not considered a threat to CSTG in Region 2. However, with oil and gas prices reaching all-time highs and with strong support from the current political administration, oil and gas exploration and development have increased dramatically throughout the West. This activity has expanded into the core range of CSTG in Region 2. Impacts of oil and gas development include direct habitat loss and fragmentation from well, road, and pipeline construction; displacement (i.e., avoidance behavior) of individuals caused by excessive human activity; increased avian predation due to the construction of artificial perch sites; and increased mortality due to collisions with utility lines and vehicles. If oil and gas resources in Region 2 are developed to their fullest potential, the outcome could be devastating to CSTG populations.

The most essential component of habitats used by CSTG during winter in Region 2 is the presence of serviceberry (*Amelanchier* spp.). Serviceberry is the primary food source for CSTG from late fall through early spring. Any activity that reduces the distribution and abundance of serviceberry may have negative consequences to CSTG.

Primary Conservation Elements, Management Implications and Considerations

The keys to successful management of CSTG in Region 2 are protection and enhancement of existing habitats and restoration of habitats that are no longer occupied or are severely degraded. The natural processes that perpetuate the habitats upon which CSTG rely have been significantly disrupted by human activities and are no longer intact. Consequently, in most situations, some form of human intervention is necessary to correct the problems. This may be as simple as eliminating the activity causing the problem and allowing the plant community to recover on its own, or it may involve extensive restoration of the plant community. Protection and management of native cover types should receive top priority. There should be no net loss of sagebrush, shrubsteppe, or mountain shrub cover types in Region 2. Some of the same activities responsible for the loss and degradation of shrubsteppe and mountain shrub habitats also may be used to enhance and restore these habitats when properly applied. These activities include prescribed fire, grazing, use of herbicides, and mechanical treatments. Managers must be acutely aware that multiple factors affect CSTG populations, and they should consider the cumulative effects of these factors when formulating any future management actions.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS) Rocky Mountain Region (Region 2). The Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*; CSTG) is the focus of an assessment because Region 2 lists it as a sensitive species, and conservation of sensitive species is to be integrated into National Forest System land management planning. The CSTG is classified as a sensitive species within Region 2 due to its restricted distribution and limited population size. The CSTG also is of special concern within Region 2 and throughout its range because it has been petitioned twice for federal listing under the Endangered Species Act. Only a single metapopulation exists within Region 2, and it is disjunct from the nearest other populations in Utah and Idaho. This alone is sufficient reason the subspecies requires special management attention.

This assessment addresses the biology and conservation of the CSTG throughout its historic and current ranges, focusing more specifically on Region 2 (**Figure 1**). The broad nature of the assessment leads to some constraints on the specificity of information for particular locales. Completing the assessment required the establishment of limits concerning the geographic scope of particular aspects of the assessment. This introduction defines the goal of the assessment, outlines its scope, describes the information used to produce the assessment, and discusses the process used in its production.

Goal

Species conservation assessments produced for the Species Conservation Project are designed to provide forest managers, research and management biologists, other agencies and organizations, and the public with a comprehensive discussion of the
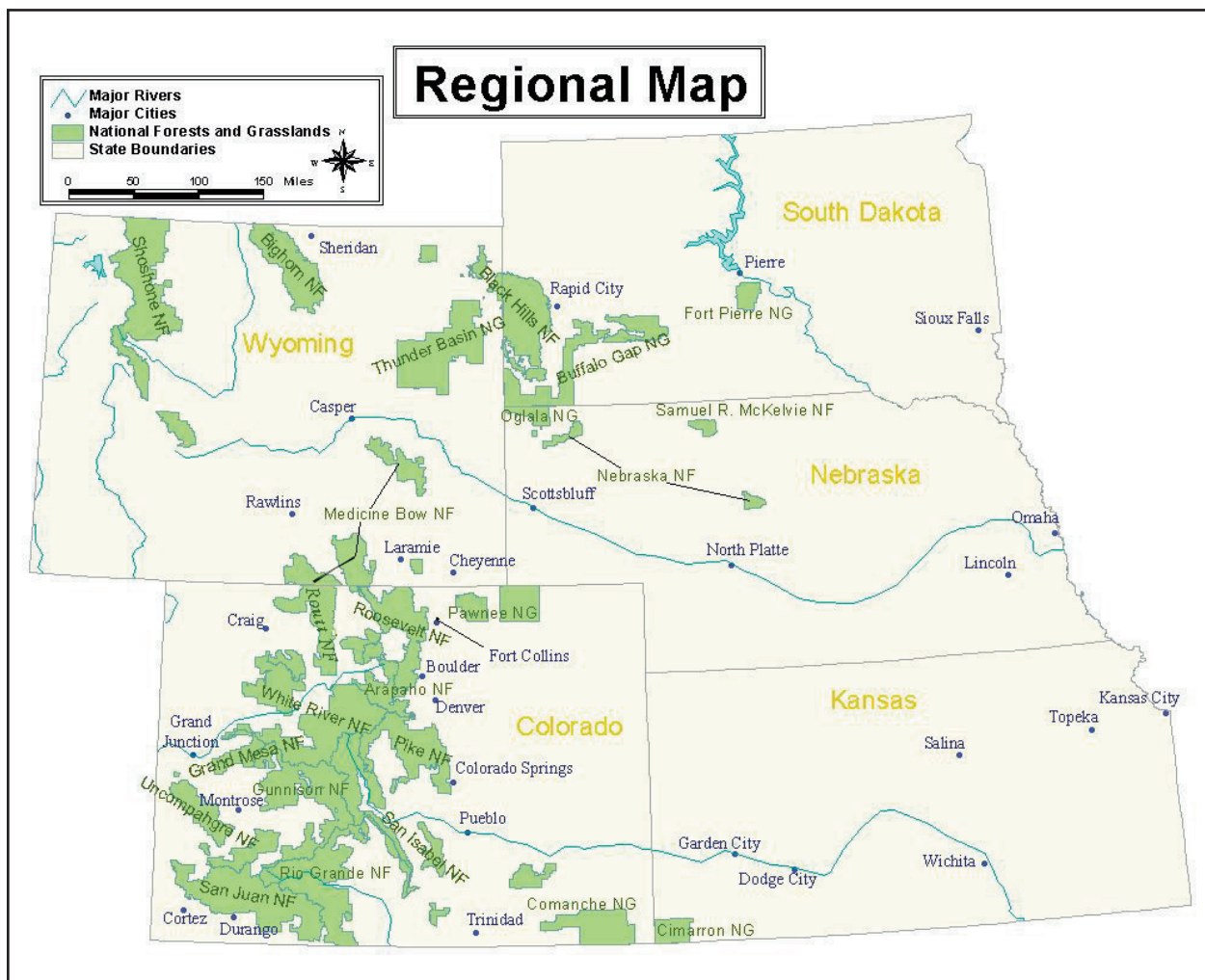
Figure 1. National forests and grasslands of USDA Forest Service Rocky Mountain Region.

biology, ecology, conservation status, and management requirements of selected species based on scientific knowledge accumulated prior to initiating the assessment. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The ultimate goal is to provide managers with an ecological framework upon which to formulate sound decisions. This assessment identifies threats to CSTG and implications if these threats are left unchecked. It cites previously published recommendations and examines the success or failure of recommendations that have been implemented. Additionally, the assessment provides management strategies not previously proposed elsewhere along with insight into the consequences of changes in the environment that result from management (i.e., management implications).

Scope

This assessment examines the biology, ecology, management, and conservation of CSTG with specific reference to the geographic and ecological characteristics of the USFS Region 2. Two subspecies of sharp-tailed grouse occur within Region 2. The focus of this assessment is on the Columbian subspecies. Some of the literature on this subspecies originates from field investigations and planning outside of Region 2. This document places that literature in the ecological and social context of Region 2. This assessment is concerned with the reproductive behavior, population dynamics, habitat relationships, and other characteristics of CSTG in context of the current environment rather than under historical conditions. The historical environment of the subspecies is considered in conducting the synthesis, but placed in context with the current environment.

Data Used to Produce This Assessment

In producing the assessment, information was gathered from peer-reviewed sources, theses, dissertations, agency and university technical reports, research reports, and data accumulated by resource management agencies. Non-refereed information was used where this information was deemed reliable and necessary to fill knowledge gaps. The nature of this information is clearly acknowledged and used with caution. Not all publications on CSTG are referenced in the assessment, nor are all published materials considered equally reliable. In reviewing the literature, it was discovered that several publications contained redundant information. Therefore, it was not necessary to cite all of them. The assessment emphasizes refereed

literature because this is the accepted standard in science. However, even peer-reviewed literature has its strengths and weaknesses. If new information refutes previously published data, the discrepancies are noted. In addition, the strengths of particular ideas are evaluated, and alternative explanations are described when appropriate.

A concerted effort was made to collect, review, and evaluate all pertinent information (published and unpublished) on the management status, natural history, and conservation of CSTG. This included reviewing literature on other subspecies of sharp-tailed grouse and on other species of grouse and incorporating this information into the assessment where it was relevant to CSTG and Region 2. Users of this assessment should be aware that although there is a wealth of information on sharp-tailed grouse, there is a dearth of published literature on the Columbian subspecies. This is because early on, populations were severely reduced or extirpated in many states, thus, opportunities for study were limited. Storch (2000) places the number of scientific and semi-scientific publications on sharp-tailed grouse at slightly over 400. Of the 17 grouse species listed by Storch (2000), the sharp-tailed grouse ranks 6th in available publications. Probably less than 100 of the publications on sharp-tailed grouse pertain to the Columbian subspecies.

Plant names used in this assessment follow the USDA Plants Database available at http://www.plants.usda.gov.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. Since our descriptions of the world are incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, it is often difficult to conduct experiments that produce clean results. This is frequently true in the ecological sciences because of the number of variables that one must consider and control for. Consequently, we often must rely on observations, inferences, sound thinking, and models to guide our understanding of ecological relations. Such is the case for CSTG. Much of the published information on CSTG originates from descriptive rather than experimental studies. Even so, alternative approaches such as modeling, critical assessment of observations (i.e.,

descriptive studies), and inferences have contributed greatly to our understanding of the ecology of CSTG. This assessment describes accepted knowledge about the Columbian subspecies and identifies weaknesses in that knowledge. **Users of this assessment are strongly encouraged to read the document in its entirety. Otherwise, single statements may be taken out of context or misinterpreted.**

Publication of Assessment on the World Wide Web

To facilitate use of species assessments produced by the Species Conservation Project, they are published on the USFS Region 2 World Wide Web site at http://www.fs.us/r2/projects/scp/assessments/index.shtml. Placing the documents on the Web makes them available to potential users more rapidly than publishing them as reports, and it simplifies future revisions and inclusion of new information.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to release. This document was reviewed through a process administered by the Society for Conservation Biology. Two recognized experts provided critical review of the manuscript. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Taxonomists have long debated the validity of designating taxa below the species level (reviewed by Haig et al. 2006). Careless taxonomy and over-application of the subspecies concept for species that attract human interest have exacerbated the debate. However, this does not invalidate the concept of subspecies as a meaningful biological entity. Management of definable subspecies is essential for maintaining biological diversity and insuring evolutionary potential within the species (Haig et al. 2006). This is one reason why the U.S. Endangered Species Act allows for the listing of subspecies and other groupings below the species rank. Thus, although the CSTG is only one of six existing subspecies of sharp-tailed grouse, this does not diminish its importance in the conservation of the species. On the contrary, Miller

and Graul (1980) identified the CSTG as the subspecies of sharp-tailed grouse most in need of conservation.

The U.S. Fish and Wildlife Service (USFWS) does not consider the CSTG to be a bird of conservation concern, despite being petitioned twice for listing (U.S. Department of Interior 2002). The Biodiversity Legal Foundation petitioned to list CSTG in 1995 as threatened in the lower conterminous United States pursuant to the Endangered Species Act (Carlton 1995). The USFWS did not act on the petition until October 1999, at which time the Service ruled the petition contained sufficient information to warrant a full assessment of the subspecies' status. On 11 October 2000, the USFWS issued its 12-month finding that the petition to list CSTG as a threatened subspecies throughout its historic range in the contiguous United States was not warranted (U.S. Department of Interior 2000). In making this finding, the USFWS retained the option to list CSTG should additional information become available to indicate such action was appropriate and warranted. The Service also retained the option of recognizing discrete populations for listing if information becomes available to warrant such action.

Forest Guardians filed the second petition to list the CSTG on 14 October 2004 (Banerjee 2004). After being sued, the USFWS subsequently acted on the petition. On 21 November 2006, the USFWS issued a 90-day finding that the petition did not provide sufficient information to indicate that listing CSTG was warranted, and therefore, the Service would not initiate a status review in response to the petition (U.S. Department of Interior 2006).

The Natural Heritage Program (http://www.natureserve.org/explorer, accessed 12 August 2006) has given CSTG a global rank of G4T3, indicating as a species the sharp-tailed grouse is secure throughout its range, but the Columbian subspecies is vulnerable to extirpation or extinction. National rankings are N3 (vulnerable to extirpation or extinction) for the United States and N2N3 (imperiled to vulnerable) in Canada. State and Provincial rankings are as follows: British Columbia (S2S3: imperiled to vulnerable), California (SX: extinct), Colorado (S2: imperiled), Idaho (S3: vulnerable), Montana (S1: critically imperiled), Nevada (S1?: critically imperiled, pending success of reintroduction program), Oregon (S1: critically imperiled), and Wyoming (S1: critically imperiled). Heritage Programs in Washington and Utah do not provide specific rankings for CSTG because they only track at the species level. However, since the CSTG is

the only subspecies of sharp-tailed grouse in Washington and Utah, the species level rankings (Washington: S2 imperiled; Utah S1S2 critically imperiled to imperiled) are in essence for the CSTG.

In 1993, the British Columbia Ministry of Environment, Lands and Parks Wildlife Branch blue listed the CSTG (Ritcey 1995). In 1998, the Washington Department of Fish and Wildlife classified CSTG as threatened (Hays et al. 1998). Most other states where the CSTG still occurs, including Colorado, Wyoming, Idaho, Montana (recently extirpated), and Utah, identify it as a bird of special concern. It is on the Watch List of birds in Nevada and is not classified in Oregon and California. Columbian sharp-tailed grouse are legally hunted in British Columbia, Colorado, Idaho, and Utah.

USFS Region 2 has designated the CSTG as a sensitive species. It also is on the sensitive species list for Regions 3 (Southwest), 4 (Intermountain), and 6 (Pacific Northwest), but it will soon be removed from the list for Region 3 because it no longer occurs there. Although the CSTG occurs in Region 1 (Northern), it is not found on USFS lands there and, therefore, is not listed as a sensitive species by the USFS in this Region.

The Bureau of Land Management (BLM) designates sensitive species by states rather than Regions. The BLM classifies the CSTG as a sensitive species in every state where it occurs on BLM lands. Only two states (Colorado and Wyoming) within Region 2 of the USFS support CSTG. In both states, the BLM lists the CSTG as a sensitive species.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Within Region 2, state and federal agencies have limited regulatory authority to protect habitats of CSTG because only about 32 percent of the occupied

range occurs on public lands. The USFS administers approximately 4 percent of the occupied habitat of the CSTG in Region 2 (**Table 1**). Addressing the problems associated with the conservation of CSTG depends upon the involvement and cooperation between federal and state agencies, and private landowners.

USFS Region 2 includes the CSTG on the Regional Forester's sensitive species list, and by policy (U.S. Department of Agriculture 2003) Region 2 must actively manage for CSTG to avoid trends towards federal listing and to maintain viability. The Region must develop and implement conservation strategies for sensitive species and their habitats in coordination with other USFS units, other state and federal agencies, and private landowners. This may include collaboratively developing individual or multi-species conservation strategies, formalizing interagency conservation agreements, and incorporating recommendations into management direction set forth in Land and Resource Management Plans. The Region also must prepare Biological Evaluations on the potential effects to sensitive species of any proposed actions on lands under their administration. The USFS must integrate scientific information from regional species evaluations, species and ecosystem assessments, and conservation strategies into their planning and implementation process. Appropriate inventories and monitoring of sensitive species must be conducted in coordination with other agencies and partners to improve knowledge of the species' distribution, status, and responses to management activities.

State and Canadian Provincial wildlife agencies have complete management responsibilities for CSTG because it is not federally listed or covered by any acts or treaties, such as the Migratory Bird Treaty Act, that may supersede the authority of the state or province. These agencies develop regulations, set hunting seasons, and monitor harvest. In Region 2, Colorado and Wyoming classify the CSTG as a game species, but due to its restricted distribution and small population size, the CSTG is not legally hunted in Wyoming.

Table 1. Approximate distribution of land ownership (km^2) within the occupied range of Columbian sharp-tailed grouse in USDA Forest Service Rocky Mountain Region.

Land status	Colorado (%)	Wyoming (%)	Region 2 (%)
Public	1,543 (25)	970 (61)	2,513 (32)
USDA Forest Service	206 (3)	92 (6)	298 (4)
Private	4,730 (75)	618 (39)	5,348 (68)
Totals	6,273	1,588	7,861

Columbian sharp-tailed grouse are hunted in Colorado. Areas open to hunting are restricted to nine small game hunting units in portions of Moffat, Routt, and Rio Blanco counties in northwestern Colorado. This represents approximately 70 percent of the known occupied range of CSTG in Colorado, excluding areas where CSTG have recently been transplanted. Season length varies from 16 to 22 days, opening on 1 September and closing following the third weekend in September. Bag and possession limits for CSTG were in aggregate with sage-grouse (*Centrocercus* spp.) until 1981. From 1981 to 1991, bag and possession limits were three and six sharp-tailed grouse, respectively. From 1992 to 1994, the possession limit was increased to nine sharp-tailed grouse, and the bag limit remained at three sharp-tailed grouse per day. The bag and possession limits were reduced in 1995 to two and four, respectively, and currently remain at these levels.

Until 1995, harvest estimates in Colorado were obtained using a post-season mail survey of a sample (3 to 5 percent) of small game license buyers. Hunters were required to obtain a special permit (free and unlimited in number) from 1995 to 1997 to hunt sharp-tailed grouse. The purpose of the permit system was to gather more precise harvest information than could be obtained from the mail survey of small game license holders. Both a post-season mail survey (5 percent of small game license holders) and a telephone survey (100 percent of permit holders) were conducted each year during 1995, 1996, and 1997. Currently, harvest estimates for Colorado are calculated using telephone surveys based on information obtained from the Harvest Information Program (HIP, available at http://www.colohip.com). This is a joint program between the Colorado Division of Wildlife (CDOW) and USFWS, designed to improve migratory bird and small game harvest estimates. Any small game license holder who intends to hunt must validate their license by calling the HIP phone number or registering online. At this time, they are asked a series of questions. The questioning eventually identifies those hunters who will not hunt, are somewhat likely to hunt, or are very likely to hunt CSTG. Samples for the telephone survey are then selected as: 50 percent of those very likely to hunt CSTG, 20 percent of those somewhat likely to hunt, and 10 percent of those who will not hunt.

Braun et al. (1994) considered mail surveys inadequate for estimating harvest of upland game birds because such surveys cannot be conducted in a timely fashion, response rates are low, and harvest estimates tend to be inflated due to non-response biases (successful hunters are more likely to return questionnaires). This particularly applies to lesser-hunted species, such as CSTG. A comparison of mail and telephone survey results supports this conclusion. Mail surveys grossly over-estimated the harvest six to 10-fold compared to telephone surveys (**Table 2**).

Outside of Region 2, management and conservation plans, and status assessments have been prepared for CSTG in British Columbia (Ritcey 1995), Idaho (Ulliman et al. 1998), Montana (Wood 1991), Utah (Utah Division of Wildlife Resources 2002), and Washington (Tirhi 1995). Within Region 2, a plan has been developed for northwestern Colorado (Hoffman 2001) but not south-central Wyoming. However, many of the issues and strategies related to CSTG in northwestern Colorado (Hoffman 2001) also apply to south-central Wyoming, as populations in the two areas are contiguous. At the national level, Bart (2000) prepared a range-wide conservation assessment of the CSTG for the USFWS status review team. Ulliman (1995a) also authored a range-wide conservation assessment for the CSTG and its habitats, but this document has not been approved and made public. Internationally, the worldwide conservation action plan for grouse prepared by the International Union for the Conservation of Nature and Natural Resources addresses the CSTG (Storch 2000). This document is presently in the process of being revised and updated.

In 1990, the National Fish and Wildlife Foundation brought together federal, state, and local government agencies, private foundations, conservation organizations, industry, everyday citizens, and the academic community to form Partners in Flight (PIF). This is a voluntary, international coalition dedicated to "keeping common birds common" and "reversing the downward trends in declining species." At the national level, the PIF North American Land Bird Conservation Plan recognizes the sharp-tailed grouse as an Additional Stewardship Species and has assigned it a vulnerability assessment score of 11 of a maximum of 20 (Rich et al. 2004). This plan focuses at the species level and does not recognize or rank individual subspecies. The real foundation of the PIF program is the development of land bird conservation plans for each state or physiographic region. These plans identify priority species and habitats and establish objectives for conserving, managing, and monitoring bird populations and their habitats. Plans have been developed for Colorado (Beidleman 2000) and Wyoming (Nicholoff 2003), the only two states within Region 2 where CSTG occur. Both plans have identified habitats (mountain shrublands and sagebrush shrublands) used by CSTG as priority cover types for conservation. However, only the

Table 2. Columbian sharp-tailed grouse season structure and harvest information for Colorado, 1990-2006.

Year	Season length (days)	Bag/possession limit	Number of hunters[1]	Total harvest[1]
1990	30	3/6	1,618	4,639
1991	30	3/6	1,686	2,550
1992	34	3/6	1,267	2,597
1993	33	3/6	1,157	1,761
1994	32	3/6	871	1,404
1995	17	2/4	128 (708)	111 (1,096)
1996	22	2/4	255 (900)	227 (1,327)
1997	21	2/4	97 (866)	102 (682)
1998	20	2/4	317	433
1999	19	2/4	304	328
2000	18	2/4	249	328
2001	22	2/4	236	393
2002	21	2/4	85	148
2003	20	2/4	166	336
2004	19	2/4	350	1,096
2005	18	2/4	576	679
2006	17	2/4	173	232

[1] Estimates based on mail surveys from 1990 to 1994, phone and mail surveys (in parentheses) from 1995 to 1997, and phone surveys only from 1998 to 2006.

Wyoming plan identifies CSTG as a priority bird species. The Colorado Land Bird Conservation Plan lists plains sharp-tailed grouse (*Tympanuchus phasianellus jamesi*) but not CSTG as a priority species. Future revisions of this plan should consider including CSTG as a priority species in the mountain and sagebrush shrubland types within the Southern Rocky Mountain and Colorado Plateau Physiographic Regions.

Columbian sharp-tailed grouse are one of 15 upland game birds featured in the Colorado Division of Wildlife's Upland Bird Management Analysis Guide (Braun et al. 1994). The Guide identifies and discusses 15 issues that transcend all species of upland game birds (not all issues apply to CSTG), and further identifies issues specific to each species/subspecies addressed in the Guide. Three management issues specific to CSTG include:

1. Some suitable historic habitats remain unoccupied.

2. The harvest of CSTG in some areas may be excessive.

3. There is insufficient knowledge to manage habitats effectively to benefit CSTG.

Since the Guide was completed, the CDOW has implemented more conservative hunting regulations, developed a conservation plan (Hoffman 2001), initiated several studies to learn more about the habitat use patterns of CSTG (Boisvert 2002, Lassige 2002, Collins 2004), and conducted transplants of CSTG into historically occupied habitats in southwestern and north-central Colorado.

Throughout much of its present range, the CSTG occurs in close association with greater sage-grouse (*Centrocercus urophaisanus*) during the breeding, nesting, and brood-rearing periods (Apa 1998). Historically, CSTG also coexisted with Gunnison sage-grouse (*C. minimus*) and recently were reintroduced into previously occupied habitats in southwestern Colorado where Gunnison sage-grouse still occur. Greater and Gunnison sage-grouse have been petitioned for protection under the Endangered Species Act in eight petitions (reviewed by Connelly et al. 2004). This has prompted the development of a plethora of local, state, and national plans for sage-grouse and their habitats (reviewed by Connelly et al. 2004 and Gunnison Sage-grouse Rangewide Steering Committee 2005). These plans contain conservation strategies for managing sage-grouse populations and their habitats. Hoffman (2001) recommended that

where CSTG and sage-grouse coexist, plans for managing sage-grouse habitats should take precedence. This recommendation was based on the contention that managing for sage-grouse will benefit or at the very least not harm CSTG populations.

Biology and Ecology

Systematics and general species description

Columbian sharp-tailed grouse belong to the order Galliformes, Family Phasianidae, and subfamily Tetraoninae. Sharp-tailed grouse have occupied western and northern North America since late Pleistocene. Fossil records of two extinct species of sharp-tailed grouse (*Pedioecetes lucasi* and *P. nanus*) have been reported from Pleistocene deposits at Fossil Lake, Oregon (Wetmore 1959). The sharp-tailed grouse was originally described in 1758 as *Tetrao phasianellus* by Linnaeus and subsequently placed in the monotypic genus *Pedioecetes* by Baird in 1858. The sharp-tailed grouse maintained its monotypic status until 1982 when it was classified as congeneric with prairie-chickens and moved to the genus *Tympanuchus* (American Ornithologists' Union 1983).

There are six existing and one extinct subspecies of sharp-tailed grouse in North America, including three southern and four northern forms:

Southern Forms:
T. p. columbianus – Columbian sharp-tailed grouse
T. p. jamesi – Plains sharp-tailed grouse
T. p. hueyi – New Mexico sharp-tailed grouse (extinct)

Northern Forms:
T. p. caurus – Alaskan sharp-tailed grouse
T. p. kennicotti – Northwestern sharp-tailed grouse
T. p. phasianellus – Northern sharp-tailed grouse
T. p. campestris – Prairie sharp-tailed grouse

The Columbian subspecies was first discovered by Lewis and Clark in 1805 and originally named by Ord in 1815 (Bent 1963). Lewis and Clark encountered the birds on the shrubsteppe plains of the Columbia River Basin, hence the name "Columbian" sharp-tailed grouse. The species name *phasianellus* is derived from the Greek word *phasianous* meaning little pheasant (Terres 1980). Vernacular names for the sharp-tailed grouse include brush grouse, spike-tail, pintail, spring-tail, speckle-belly, prairie pheasant, white-belly, and white-breasted grouse (Johnsgard 1973).

Ellsworth et al. (1995) reported that the genetic differentiation between sharp-tailed grouse and prairie-chickens is among the lowest in closely related species of birds. Hybridization between sharp-tailed grouse and greater prairie-chickens (*Tympanuchus cupido*) is common where the ranges overlap, with F_1 hybrids and backcrosses being fertile (Sparling 1980). The range of the Columbian subspecies does not overlap with the range of greater or lesser (*T. pallidicinctus*) prairie-chickens, but it does overlap with the range of dusky grouse (*Dendragapus obscurus*), greater sage-grouse, and Gunnison sage-grouse. Dusky grouse have been observed on CSTG leks in northwestern Colorado (R.W. Hoffman personal observation). Only one documented case of a sharp-tailed grouse x blue (dusky) grouse hybrid is recorded in the literature (Brooks 1907). Several cases of hybridization between greater sage-grouse and sharp-tailed grouse have been reported (Eng 1971, Kohn and Kobriger 1986, Aldridge et al. 2001). None of these accounts involved the Columbian subspecies. In spring 2002, three Columbian sharp-tailed grouse x greater sage-grouse hybrids were observed on a sage-grouse lek in northwestern Colorado (R.W. Hoffman personal observation). One specimen was collected and is in the Denver Museum of Nature and Science (Accession number 2002-33, R.W. Hoffman, Colorado Division of Wildlife, unpublished data).

Among the 12 species of grouse in North America, the sharp-tailed grouse ranks 7th in size. It is the most sexually monomorphic of the lek breeding Tetraoninae in both plumage and body size. Adults measure 41 to 47 cm in length. Distinguishing features include a rounded body with short legs; short, pointed (wedge-shaped) tail with elongated central rectrices (tail feathers); white spots on the primary wing feathers; and V-shaped markings on the breast (Tirhi 1995, Connelly et al. 1998). Both males and females produce a characteristic clucking sound when taking flight and fly in a straight or curvilinear pattern with alternating rapid wing beats followed by periods of gliding.

Overall, sharp-tailed grouse have a mottled brown, cryptic coloration. The head, back, and wings are heavily barred with dark brown, blackish, and buff coloration. Breast-feathers are white, with tawny drab margins, and the upper belly-feathers are white, with small dark olive brown subterminal V-shaped marks that fade towards the abdomen; undertail-coverts are white.

The white under-parts are conspicuous in flight. Nostrils and legs are feathered, and the toes have pectinations on the sides for walking on snow. Each gender has crescent-shaped, yellowish orange combs over the eyes. The combs are more prominent in males during the breeding season. Crown feathers are elongated and form a crest when erected.

The CSTG is the smallest subspecies of sharp-tailed grouse and tends to have a grayer plumage, more pronounced spotting on the throat, and narrower markings on the undersides (Johnsgard 1973). Fully-grown CSTG weigh on average between 640 and 800 g depending on gender, age, season of year, and geographic area. Males (average = 700 to 800 g during spring) weigh more than females do (average = 640 to 720 g during spring) (Meints 1991, Giesen 1992, Apa 1998, Boisvert 2002, Collins 2004), and within gender, adults weigh more than subadults do. Males and females appear similar in size, shape, and coloration unless the males are displaying and exposing the violet-colored air sacs on each side of the neck. The most reliable way to distinguish gender is from close examination of the crown feathers and two central tail feathers. Females have alternating brown and buff colored crosswise barring on the crown feathers, whereas the crown feathers of males are darker brown with buffy edges and lack barring (Henderson et al. 1967). The two central tail feathers are linearly barred in females and longitudinally barred in males (Henderson et al. 1967).

Sharp-tailed grouse can be separated into adults and subadults (yearlings) during most of the year based on shape and wear of the two distal primary feathers (Ammann 1944, Giesen 1999). During late summer and early fall, experienced observers can identify three age classes: adults ($\geq$ 2 years), subadults (approximately 14 to 15 months), and juveniles (approximately 3 to 4 months). Once yearlings replace their two distal primaries, usually in early to mid-September, they cannot be distinguished from adults. Presence of juvenal secondaries and tertials are additional characteristics that can be used to separate juveniles from adults and subadults (Giesen 1999). Age classification of sharp-tailed grouse can be difficult at certain times of the year because differences between age classes can be subtle.

Distribution and abundance

Historically, sharp-tailed grouse inhabited 21 states, six Canadian provinces, and two Canadian territories (Aldrich 1963, Miller and Graul 1980, Connelly et al. 1998). The species currently occurs throughout much of its historical range in Canada,

except southern British Columbia (Ritcey 1995, Connelly et al. 1998). In contrast, the range within the United States has declined dramatically. The species has been extirpated from California (Starkey and Schnoes 1976), Illinois (Miller and Graul 1980), Iowa (Grant 1963), Kansas (Miller and Graul 1980), Nevada (Wick 1955), New Mexico (Dickerman and Hubbard 1994), Oklahoma (Sutton 1974), and Oregon (Olsen 1976). In many states where the species still occurs, the occupied range has declined to a fraction of the historical range (Miller and Graul 1980).

The Columbian subspecies formerly occurred across approximately 867,000 km^2 of suitable habitat in the western United States (780,000 km^2) and Canada (87,000 km^2) in portions of British Columbia, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming (**Figure 2**; Aldrich 1963, Miller and Graul 1980, Bart 2000). The CSTG has the dubious distinction of being considered the most well known and abundant upland game bird in the Pacific Northwest (Bendire 1892), and one of the most striking examples of the reduction in game bird populations in the western United States (Marshall and Jensen 1937). Of the six existing subspecies of sharp-tailed grouse, the Columbian subspecies has experienced the greatest decline in distribution and abundance (Hamerstrom and Hamerstrom 1961, Miller and Graul 1980). The entire United States breeding population has been estimated at 51,000 to 52,000 grouse based on the best available data provided by the individual states to the USFWS in response to the petition to list the CSTG (U.S. Department of Interior 2000). The breeding population range-wide has been estimated at 56,000 to 61,500 grouse. Within the United States, the current occupied range encompasses approximately 38,400 km^2 (U.S. Department of Interior 2000). This represents an alarming 95 percent reduction in overall range from historic levels.

Over 95 percent of the breeding population occurs within three metapopulations: northwestern Colorado and south-central Wyoming, southeastern Idaho and northern Utah, and south-central British Columbia. Idaho supports about 55 percent of the remaining population, followed by British Columbia, Utah, and Colorado. Only remnant populations (<1,000 breeding birds) remain in Washington and Wyoming. The subspecies is believed to have disappeared from Montana within the past five years (R.D. Northrup personal communication 2005), and has long (>50 years) been extirpated from California (Starkey and Schnoes 1976), Nevada (Wick 1955), and Oregon (Olsen 1976).
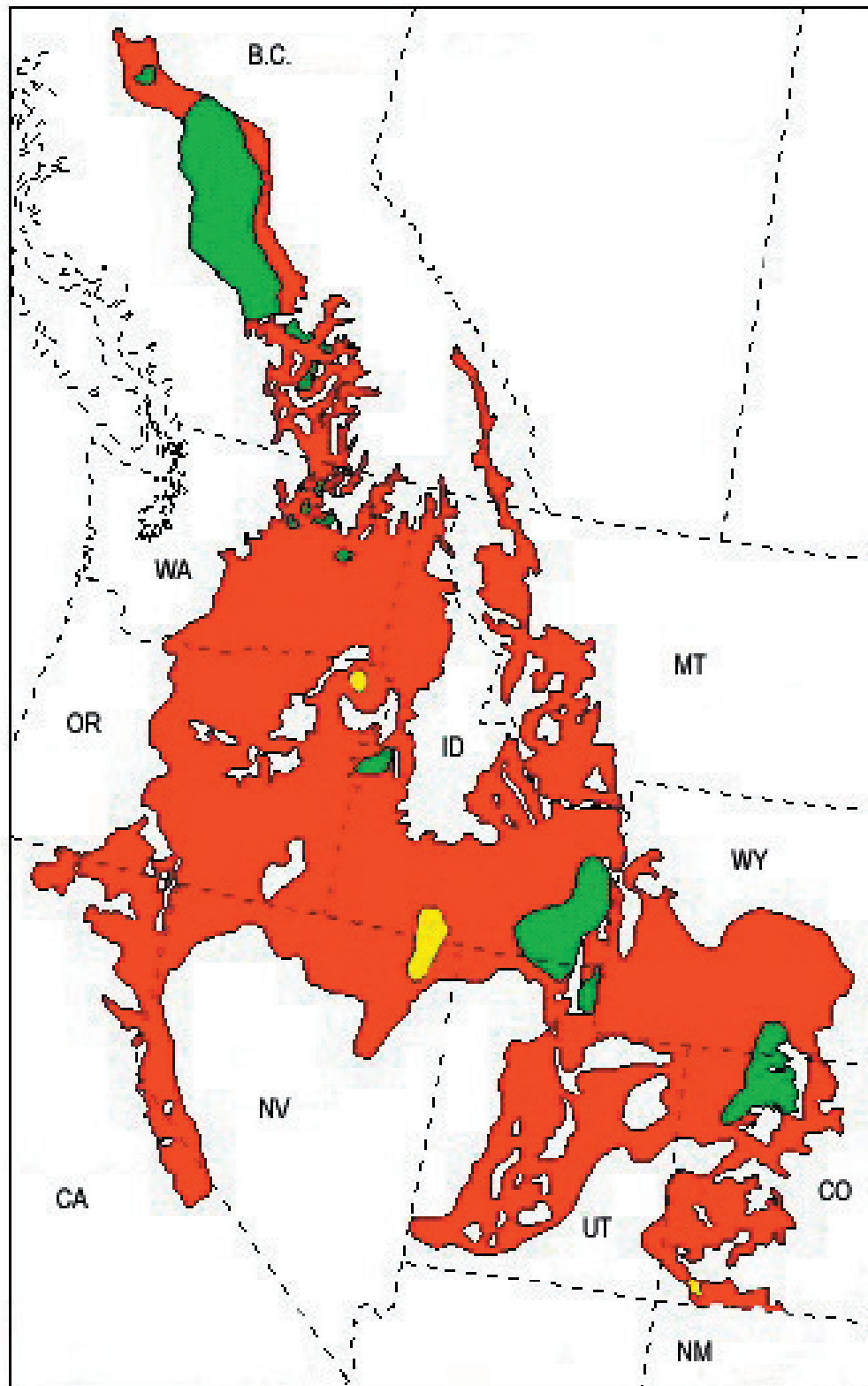
Figure 2. Historic (red) and current ranges (green = natural populations, yellow = reintroduced populations) of Columbian sharp-tailed grouse in western North America.

Attempts have been made to reintroduce CSTG into formerly occupied ranges in Idaho (Gardner 1997), Montana (Cope 1992), Nevada (Coates 2001), and Oregon (Crawford and Snyder 1995, Snyder et al. 1999, Crawford and Coggins 2000) and to supplement existing populations in Washington (Schroeder and Peterson 1998). The releases in Montana were unsuccessful. The probability of long-term success for releases in Nevada and Idaho appears high. The success of the releases in Oregon remains uncertain. Columbian sharp-tailed grouse still persist in Oregon, but the population is critically small (<50 grouse) and has not increased in abundance or distribution. Plans are to release more birds in Oregon to supplement the existing population (D.A. Budeau personal communication 2006). Supplemental releases in Washington were conducted in an effort to maintain a small population on the Scotch Creek Wildlife Area until habitat improvement projects could be completed. The supplemental releases appeared to work as lek counts increased the following spring. Additional supplemental releases were conducted in Washington in 2005 and 2006 on the Swanson Lakes Wildlife Area and Colville Indian Reservation (M.A. Schroeder personal communication 2005).

Within Region 2, CSTG only occur in Colorado and Wyoming (**Figure 3**). Plains sharp-tailed grouse occur in Region 2 in Colorado, Wyoming, Nebraska, and South Dakota. Ranges of the two subspecies in Wyoming are less than 225 km apart. Historically, the two subspecies may have occupied habitats in central Wyoming within 100 km of each other. Lack of information, unreliable information, poor record keeping, and frequent misidentification of dusky grouse and sage-grouse for sharp-tailed grouse have made it difficult to track the status and distribution of this grouse in Colorado and Wyoming. The distribution is more clearly documented in Colorado (Rogers 1969, Giesen and Braun 1993, Hoffman 2001) than in Wyoming (Oakleaf et al. 1982).

Private lands comprise 68 percent of the occupied range in Region 2. Four percent (Colorado = 3 percent, Wyoming = 6 percent) of the occupied range of CSTG in Region 2 occurs on lands administered by the USFS in portions of the Routt, Medicine Bow, and White River national forests **(Table 1**, **Figure 3**). The historical range in Region 2 also included portions of the San Juan, Grand Mesa-Uncompahgre-Gunnison, and possibly the Rio Grande, Arapaho-Roosevelt, and Shoshone national forests. Within Wyoming, the historical range extended into the Bridger-Teton National Forest, which is part of Region 4.

Scattered populations of CSTG likely occurred throughout suitable habitats in northwestern, west-central, southwestern, and south-central Wyoming. Fuller and Bole (1930) reported observing sharp-tailed grouse near Pinedale, Wyoming, and Sharritt (1946) mentions the presence of sharp-tailed grouse on the National Elk Refuge near Jackson. Columbian sharp-tailed grouse are currently present or were historically present within all the counties in Utah and Idaho that border western Wyoming (Bart 2000, Utah Division of Wildlife Resources 2002). There is no reason to believe these populations did not extend into western Wyoming. Based on available information, it is likely CSTG historically occurred in Teton, Lincoln, Uinta, Park, Hot Springs, Fremont, Sublette, and Carbon counties, and possibly in Natrona, Washakie, and Big Horn counties, Wyoming.

Presently, the only known breeding population of CSTG in Wyoming is restricted to the south-central part of the state in Carbon County within and immediately west and north of the Medicine Bow National Forest (Bart 2000). This population is an extension of a larger population in northwestern Colorado (Hoffman 2001). The total occupied range in Wyoming encompasses about 1,588 km^2, of which 61 percent is publicly owned and 39 percent is privately owned. The USFS, BLM, and State of Wyoming (primarily State Trust Lands) respectively administer 6, 39, and 16 percent of the occupied range of CSTG in Wyoming.

Twenty-eight lek sites have been identified in south-central Wyoming. The highest count occurred in 2005 when 458 grouse were counted on 13 leks (**Table 3**). Bart (2000) conservatively estimated the Wyoming population at 500 grouse, and suggested that the actual population is probably much larger. Intensive surveys to locate new leks have not been conducted in Wyoming, but local wildlife agency personnel are confident more leks are present in south-central Wyoming than located to date (T.P. Woolley personal communication 2005).

Bailey and Niedrach (1965), citing numerous other sources (Morrison 1888, Gilman 1907, Cary 1909, Cooke 1909, Marsh 1931), provide direct and indirect evidence of CSTG inhabiting portions of western Colorado from La Plata County north to Moffat and Routt counties. Rogers (1969) reported that by the early 1960's, CSTG only occurred in eight counties in Colorado: Dolores, Gunnison, Mesa, Moffat, Montezuma, Montrose, Rio Blanco, and Routt. By the early 1990's, the distribution of CSTG in Colorado was restricted to Routt, Moffat, Rio Blanco, and Mesa counties (Giesen and Braun 1993).
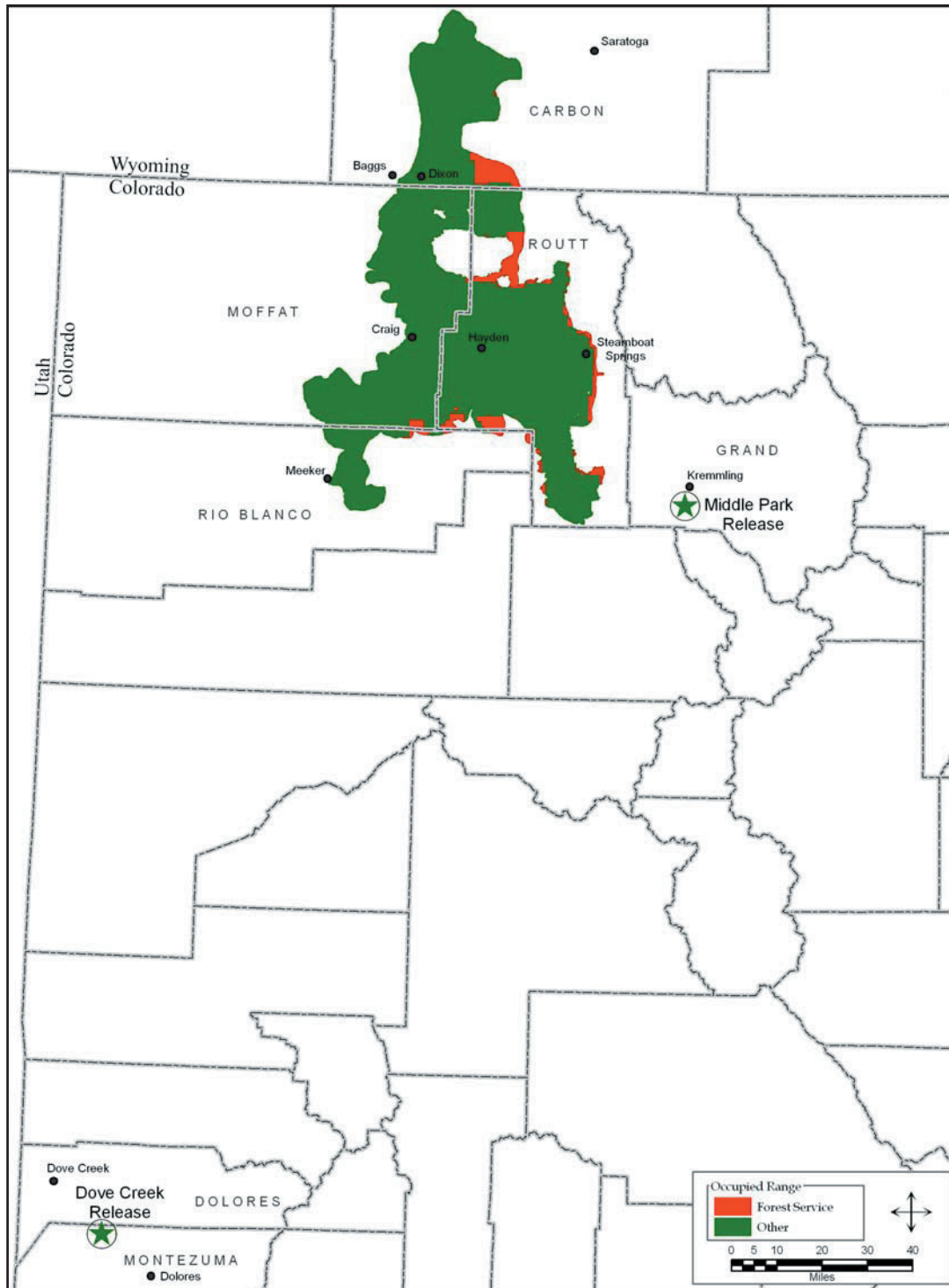
Figure 3. Distribution of Columbian sharp-tailed grouse within the Rocky Mountain Region of the USDA Forest Service.

Table 3. Total number of Columbian sharp-tailed grouse counted on leks in south-central Wyoming, 1999-2006.

	1999	2000	2001	2002	2003	2004	2005	2006
Total leks counted	9	15	9	10	11	12	13	13
Total grouse counted	114	196	134	220	327	368	458	362

The exact historical range of CSTG in Colorado is poorly documented. Rogers (1969) and Giesen and Braun (1993) suggested CSTG may have inhabited as many as 22 counties in western Colorado. However, this distribution may be exaggerated. Specimens and/or documented lek sites of CSTG are only available from Summit, Grand, Pitkin, Moffat, Montrose, Delta, Rio Blanco, and Routt counties. Valid sightings are reported from Montezuma, Dolores, La Plata, Garfield, Gunnison, San Miguel, Ouray, Jackson, and Eagle counties. There are questionable or unconfirmed records of CSTG from Archuleta, Saguache, Mineral, and Hinsdale counties. Bailey and Niedrach (1965) mention the existence of 20 skins collected from Moffat, Routt, Pitkin, and Grand counties. Giesen and Braun (1993) reported examining 13 specimens of CSTG from Moffat, Routt, Grand, and Summit counties in the Denver Museum of Natural History. They did not find specimens from Pitkin County as reported by Bailey and Niedrach (1965).

Columbian sharp-tailed grouse are currently known to occur in Moffat, Routt, and Rio Blanco counties, Colorado. This population is contiguous with the population in south-central Wyoming in Carbon County. In addition, in fall 2004, spring 2005, spring 2006, and spring 2007, CSTG were reintroduced into formerly occupied habitats in southwestern Colorado in Montezuma County near the boundary with Dolores County. In addition, in fall 2006 and spring 2007, two of four scheduled transplants were made to Middle Park in Grand County. At least 5 years of monitoring will be necessary before any conclusions can be made about the success or failure of CSTG to establish a self-sustaining population in Dolores, Montezuma, or Grand counties. The last confirmed sightings of CSTG on leks from anywhere else in the state are from Mesa County in 1985 (Giesen 1985). Efforts to locate CSTG in Mesa County in the early 1990's were unsuccessful (R.W. Hoffman unpublished data). Biologists observed two sharp-tailed grouse on the Radium State Wildlife Area in Grand County while flying deer surveys in January 2004 (A.A. Holland personal communication 2006). However, no leks have been documented in this area.

The total occupied range of CSTG in Colorado is 6,273 km^2. This estimate only pertains to the occupied range within Moffat, Routt, and Rio Blanco counties. Bart (2000) estimated the occupied range in Colorado as 10,350 km^2. This estimate includes portions of Mesa County where sharp-tailed grouse are believed to no longer occur. In contrast to Wyoming, most (75 percent) of the occupied range in Colorado is privately owned. The USFS and BLM administer 3 and 13 percent of the occupied range, respectively, and the State of Colorado administers 9 percent primarily in the form of State Trust Lands (6 percent). Most State Trust Lands in Moffat, Routt, and Rio Blanco counties are leased for surface use (i.e., grazing and crop production) and mineral extraction, and the lessee controls the access. Although State Trust Lands are publicly owned, in essence, they are managed and treated as privately owned. The public only has seasonal access to certain parcels of State Trust Lands that are leased by the CDOW for hunting and fishing privileges.

Intensive lek surveys conducted in northwestern Colorado since 1997 have resulted in the location of 250 lek sites in Routt (184; 74 percent), Moffat (65; 26 percent), and Rio Blanco (1; <1 percent) counties, of which a minimum of 192 (77 percent) have been active at least two of the past three years (**Table 4**). Nearly 89 percent of the known lek sites are on private lands. Only four (14 percent) of the 28 leks on public lands occur on lands administered by the USFS. Most (17; 61 percent) of the leks on public lands are on State Trust Lands. The remaining seven leks are on lands administered by the BLM (four) and Colorado State Parks (three leks). The average number of males counted on leks over the past 10 years (1997–2006) has fluctuated from 11.9 to 19.3 and has averaged 16.5 (**Table 4**).

Table 4. Columbian sharp-tailed grouse lek counts and lek surveys, northwestern Colorado, 1997-2006.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Known leks	75	114	141	156	174	185	202	218	238	250
New leks located	39	27	15	18	11	17	16	20	12	12
Total leks	114	141	156	174	185	202	218	238	250	262
Leks counted	91	125	146	165	168	184	193	210	218	236
Active leks	77	94	114	133	136	143	165	175	182	203
Active leks counted	44	86	103	127	136	143	165	174	176	201
Total males counted	524	1107	1646	2454	2376	2271	2385	3317	3040	3216
Males/active lek	11.9	12.9	16.0	19.3	17.5	15.9	14.5	19.1	17.3	16.0

Hoffman (2001) estimated the minimum spring breeding population of CSTG in northwestern Colorado at 6,080 birds. At the time, Hoffman (2001) estimated that about 70 percent of the suitable habitat had been searched. Assuming the unsearched habitat supported proportionally the same number of active leks as the areas already searched, Hoffman (2001) calculated there were about 190 active leks in northwestern Colorado. Assuming a 1:1 sex ratio and an average of 16 males per lek, the breeding population was estimated as 16 males per lek X 190 leks X 2 (accounts for females) = 6,080. More recent surveys indicate that the number of active leks is greater than 190. As of spring 2006, 203 active leks have been documented in northwestern Colorado. The revised estimate suggests nearly 6,500 CSTG in the spring population. This is a minimum estimate because some areas of suitable habitat remain unsearched and other areas need to be searched more intensively.

Activity patterns and movements

Columbian sharp-tailed grouse in Region 2 occupy seasonally distinct home ranges corresponding to the spring-fall and winter periods (Boisvert 2002, Collins 2004, Boisvert et al. 2005). Analysis of 1,775 telemetry locations of radio-marked grouse in northwestern Colorado indicated that 85 percent were within 2.0 km of the lek of capture from spring through fall (Boisvert et al. 2005). In comparison, of 100 winter locations, all were greater than 3.0 km from the lek of capture (Boisvert et al. 2005). Nearly 70 percent of all (n = 148) grouse tracked to wintering areas in northwestern Colorado moved greater than 7.0 km from where they were captured on a lek (Collins 2004, Boisvert et al. 2005). Using the 95 percent fixed-kernel estimator (Worton 1989) and minimum convex polygon method (Mohr 1947), Boisvert et al. (2005) estimated the median spring-fall home range size as 86 ha (mean = 153) and 61 ha (mean = 99), respectively. Spring-fall home range size did not differ between males and females. Using the 95 percent fixed kernel estimator, Collins (2004) calculated median spring-fall home range sizes for females that varied from 65 (mean = 85) to 1,168 ha (mean = 1,446). The greater variation in home range sizes and larger home ranges reported by Collins (2004) may have been the result of drought conditions causing the birds to use larger areas. Using the minimum convex polygon method, Marks and Marks (1987) and Giesen (1997) calculated mean spring-fall home range sizes of 110 and 187 ha, respectively, for CSTG occupying native habitats in western Idaho and northwestern Colorado.

Ulliman (1995b) and Boisvert (2002) are the only investigators to report winter home range sizes for CSTG due in part to the difficulty in accessing and locating grouse at this time of year. Ulliman (1995b) reported median winter home range sizes (90 percent adaptive kernel estimator) of 59 and 187 ha over two winters and attributed the difference to the severity of the winter, with grouse using smaller home ranges during the milder winter. Boisvert (2002) reported a median winter home range size (95 percent fixed kernel estimator) of 214 ha.

Mean winter home range sizes for prairie sharp-tailed grouse in Wisconsin averaged 149 ± 31 ha for females and 212 ± 26 ha for males (Gratson 1988). Studies by Ulliman (1995b) and Boisvert (2002) also showed a similar pattern of males having larger winter home ranges than females, but the differences were not significant. Both studies were based on small sample sizes of grouse and total locations per grouse. Therefore, caution must be used in interpreting the winter home range estimates.

Spring home range size of males in Washington was 11 to 46 ha (Hofmann and Dobler 1988a). Spring ranges of females are probably larger than those of males because females venture further from leks than males in search of nest sites. However, spring home ranges for females have not been measured, and home ranges for other seasons of the year are poorly documented. Collins (2004) attempted to estimate brood ranges from time of hatch until early September for broods raised in mine reclamation and shrubsteppe cover types. During moderate and severe drought years, median brood ranges in mine reclamation were 75 ha (n = 6 broods, range = 7–230 ha) and 69 ha (n = 9 broods, range = 27–196 ha), respectively, based on a minimum of 22 locations per brood. Median brood home ranges in shrubsteppe were exceptionally large: 197 ha (n = 5, range = 85–927 ha) during the moderate drought year and 2,173 ha (n = 6, range = 23–7,203 ha) during the severe drought year. Unusually large home ranges in shrubsteppe may have been an artifact of the poor condition of this cover type due to grazing. Continuation of grazing in conjunction with the ongoing drought probably exacerbated the problem. No grazing was allowed in the mine reclamation cover type where the data were collected. Under normal growing conditions, brood ranges are probably smaller within both cover types.

Breeding season

Communal display among male grouse has been described for several species (Hjorth 1970, Johnsgard 1973). Among the 12 species of grouse in North America, greater sage-grouse, Gunnison sage-grouse, greater prairie-chicken, lesser prairie-chicken, and sharp-tailed grouse all perform communal displays during the breeding season. Males gather on traditional breeding areas called "leks" or "arenas" where they perform elaborate courtship displays and vocalizations to attract females for breeding, and to defend their position on the lek against other males (Hjorth 1970, Johnsgard 1973). This pattern is referred to as lekking behavior. The surface area of the lek or arena is subdivided into a number of small, contiguous territories each occupied by an individual male (Rippin and Boag 1974a).

The lek or arena of sharp-tailed grouse is sometimes called a dancing ground. A sharp-tailed grouse lek can vary in size from less than 40 m^2 to over 200 m^2 depending on the number of males on the lek. At the core of the lek, males are usually spaced less than 5 m apart. Males on the periphery of the lek may be spaced farther apart and have less well-defined territorial boundaries.

Males depart wintering areas and start attending leks in late March, and continue through mid- to late June (**Table 5**). During this period, they seldom venture more than 1.6 km from the lek, and most (>80 percent) remain within 1 km of the lek from March through early June (Collins 2004, Boisvert et al. 2005). Males often continue to feed, loaf, and roost together when off the lek. They arrive on the lek about 30 minutes before sunrise and may remain for up to 3 hours after sunrise depending on weather and presence or absence of females. Some males may revisit the lek in the evening, but the intensity and duration of activity are less than in the morning. Leks may contain as few as two to over 40 males. Established leks may be used for many years, even decades. Of 31 leks located by Rogers (1969) in Moffat and Routt counties in the late 1950's and early 1960's, 17 were still active in spring 2006 (Colorado Division of Wildlife, unpublished data).

The lek mating system of CSTG is best described as male dominant polygyny (Connelly et al. 1998), and it is similar to the mating system of sage-grouse and prairie-chickens (Emlen and Oring 1977, Wittenberger 1978). The basic structure of the lek consists of a central ring of dominant males surrounded by two or three outer rings of successively less dominant males (Rippin and Boag 1974a, Moyles and Boag 1981). Males established on central territories mate more frequently and are predated less often than peripheral males (Rippin 1970, Moyles and Boag 1981).

Rippin and Boag (1974b) documented the presence of a non-territorial segment of the male population consisting primarily of subadults that do not attend leks unless more than 50 percent of the established males are removed. Rippin and Boag (1974b) further demonstrated that each lek appears to have its own associated group of non-territorial males. Males rarely attend more than one lek within a breeding season and return to the same lek each spring. The pair bond is limited to courtship on the leks. Males may obtain multiple mates in a single morning and over

Table 5. Timing of seasonal movements and breeding, nesting, brood-rearing, and winter activities of Columbian sharp-tailed grouse in USDA Forest Service Rocky Mountain Region.

Activity	Approximate timing (Peak)
Movements to breeding areas	Mid-March–mid-April (late March–early April)
Breeding season[1]	Late March–mid-June (late April–early May)
Nesting season[2]	Early May–mid-July (mid-May–mid-June)
Incubation	Mid-May–early July (late May–late June)
Hatching	Early June–early July (mid- to late June)
Brood-rearing	Early June–mid-September (mid-June–late August)
Fall lekking period	Mid-September–late October (late September–mid-October)
Movements to wintering areas	Mid-October–mid-December (late October–mid-November)
Winter season	Late October–early April (late November–mid-March)

[1]Spring lekking period.
[2]Includes renesting activities.

the course of the breeding season. Typically, only a small proportion of the males on the lek are successful in attracting and mating with a female (Kermott 1982, Landel 1989, Gratson et al. 1991, Gratson 1993). Of 47 established males on four leks in southern Manitoba, 23 (49 percent) were not observed to breed, 11 (23 percent) bred once, and 13 (28 percent) bred two to 11 times; nine of the 13 males that bred more than once accounted for 54 (75 percent) of 72 observed copulations (Gratson et al. 1991, Gratson 1993).

The primary display on the lek is the dance (**Figure 4**). During the dance, males rapidly stomp their feet, click the rectrices of their upturned tail, and hold their wings outward while producing a loud cork or popping note (Lumsden 1965, Hjorth 1970). Dances are interrupted by periods of freezes, when the male is silent and does not move, but remains in the dance posture. Periods of dancing and freezing are synchronized across the lek. Larger body size has a role in the male's ability to acquire a central territory (Tsuji et al. 1994), but of the central males, the smaller males have higher courtship rates and are more successful in mating (Gratson 1993). It appears that males that dance longer, click their tail feathers faster, and have a shorter interval between corks are most successful in attracting and mating with a female (Gratson 1993).

In addition to the cork sound, males produce six other vocalizations, primarily when they are on the lek (reviewed by Connelly et al. 1998).

1. Cackle - a cackling sound given during agonistic interactions. Given most frequently when females are on the lek, but increases in frequency from early to mid-morning if females are absent.

2. Chilk - a sharp, bark-like complex note of multiple energy peaks along a wide frequency range. Given most frequently when females are present on the lek. Possibly serves a mate-attraction function. Other evidence suggests it serves to interfere with the cork note of adjacent males trying to court a female.

3. Coo - a short, low frequency cooing produced by the syrinx and amplified by esophageal air sacs. Given most frequently when no females are present on the lek. Serves to denote presence of male to other males and to females off the lek.

Figure 4. Male Columbian sharp-tailed grouse displaying (dancing) on a lek. Photograph by Richard W. Hoffman.

4. Gobble - a gobbling sound of three to five notes, each comprised of an intricate frequency structure, separated by short intervals. Associated with agonistic interactions among males when establishing territories.

5. Whine - lingering, whining sound produced during agonistic interactions. Commonly given during face-offs along territorial boundaries.

6. Cork - popping sound that resembles a cork pulled from a bottle. Given when females are on the lek. Plays a strong function in mate choice by females.

7. Cluck - three note clucking sound given by both males and females when taking flight. Given at any time of year.

The precise sex ratio in the breeding population is unknown. Giesen (1999) ascertained gender from gonadal inspection of 93 adults and 163 juveniles harvested in Colorado. The sex ratios did not differ from 1:1 (adults = 1 male:1.2 females, juveniles = 1 male: 1.1 females). Giesen (1999) acknowledged that harvest samples may not be representative of the population, but stressed that there are no other data to indicate sex ratios markedly differ from 1:1.

Within Region 2, females start to visit leks regularly about mid-April. The peak of hen attendance usually occurs in late April and early May (**Table 5**). This peak may vary by 7 to 10 days from one spring to the next depending on snow cover and spring weather conditions. Females visit leks singly or in groups of two to five individuals. Unlike sage-grouse, where the number of females on the lek may equal or surpass the number of males, this rarely is the case with CSTG. It is common for only one female to be on the lek and seldom are there more than 10 females on the lek at one time, even on larger leks. However, over the course of a single morning during the peak of breeding activities, 10 or more hens may visit a lek of 20 to 25 males. The hens come and go, usually arriving just before or slightly after sunrise. They may walk on to the lek, but generally fly to the lek, land on the periphery, and walk towards the center. They remain on the lek for 15 to 30 minutes. When leaving, they usually walk to the periphery and fly off. Occasionally they walk off into the surrounding vegetation.

Lekking behaviors and lek attendance patterns of females are less understood than for males. No evidence has been collected to suggest that some females do not attend leks. Females may attend a single lek more than once or visit multiple leks. Unlike the males, females do not attend leks on a daily basis or defend territories on the leks (reviewed by Connelly et al. 1998). Their main purpose for attending the lek is to mate. However, females may visit leks without mating.

It is assumed that females only copulate once during the breeding season unless they are disturbed while mating or they attempt to renest. However, evidence to support (Tsuji 1996) or refute (Gratson et al. 1991) this contention is inconclusive. In addition, if females successfully copulate more than once, it is unknown whether the multiple copulations are performed with the same or different males. However, it is known that if the initial copulation attempt is unsuccessful, they may or may not mate with the same male. Attempts to copulate are often disrupted (Gratson et al. 1991), in which case the female must try to mate again during the same visit or during a later visit to the lek. In either case, she may or may not mate with the same male. Gratson et al. (1991) reported that 36 percent of 204 observed copulations were disrupted. Of the 74 females involved in the disrupted copulations, only 50 percent remated with the same male, 17 percent mated with the male that disrupted the initial copulation attempt, and 33 percent mated with a different male that was not involved in the initial copulation or disruption.

Males may pursue females after they leave the lek. These males continue to display to the female off the lek. While it is believed that most copulations take place on the lek, some mating may occur off the lek (Sexton 1979). The extent of this behavior is unknown.

Females move significantly longer distances and exhibit more variation in their movements during the breeding season than males do. Based on two studies in northwestern Colorado, no males ($n = 76$) moved greater than 1.6 km from their lek of capture during spring, whereas about 20 percent of 208 females ventured over 2.0 km from their lek of capture (Collins 2004, Boisvert et al. 2005). The longest movement for a female during the breeding season was 10.1 km, compared to only 1.6 km for a male.

Nesting season

Telemetry data suggest that all females attempt to nest (Connelly et al. 1998). Of 183 radio-marked

females (subadults = 36, adults = 147) monitored during the nesting season in northwestern Colorado from 1999 to 2003, at least 180 (98 percent) attempted to nest (Boisvert 2002, Collins 2004). No definitive data exist on when females select a nest site, but Bergerud and Gratson (1988) and Gratson (1988) suggest that nest site selection may occur before mating. Males have no role in nest-site selection, construction of the nest, incubation of the eggs, or care of the young (Tirhi 1995, Connelly et al. 1998). In Region 2, nest construction and initiation of laying begins in early to mid-May, with incubation starting in mid- to late May, and hatching occurring in mid-to late June (**Table 5**; Boisvert 2002, Collins 2004). Photoperiod directly controls the timing of nesting activities, but it may be accelerated or delayed up to 14 days annually by climatic conditions. Compared to other portions of the range, breeding and nesting activities of CSTG in Region 2 are naturally later because the birds live at higher elevations.

Several studies in northwestern Colorado documented timing of nesting activities. Boisvert (2002) reported that incubation began on 19 May 1999 and 7 May 2000; the latest any female began incubating their initial nest was 13 June in both years. The peak of incubation (equal to middle third of when hens were incubating their initial clutches) was 27 to 31 May 1999 and 17 to 22 May 2000. Hatching dates ranged from 7 June to 14 July (including renests). The differences between years were attributed to warmer and drier conditions in 2000 (moderate drought year) compared to 1999 (normal year). In another study, initiation dates for initial nests ranged from 14 May to 8 June 2001 and 7 May to 10 June 2002, peak of incubation (defined above) ranged from 20 to 23 May 2001 and 15 to 20 May 2002, and peak of hatch ranged from 14 to 19 June 2001 and 10 to 16 June 2002 (Collins 2004). Hatch dates for renest clutches ranged from 2 to 14 July in 2001 and 2002. Collins (2004) emphasized that timing of nesting activities in 2001 and 2002 was probably early because of moderate (2001) to severe (2002) drought conditions. Giesen (1999) estimated hatch dates from wing samples collected in northwestern Colorado from 1980 to 1997. In 10 of the 18 years of data, the peak week of hatch was estimated as 16 to 22 June. Hatch dates ranged from 21 May to 19 July, and the median hatch date was 22 June.

The nest is a shallow depression in the ground lined with dried vegetation and several soft body feathers. The slightly oval-shaped depression ranges from 10 to 15 cm in diameter and 3 to 8 cm deep (Hart et al. 1950). Females start laying one to three days after they copulate and lay subsequent eggs at one to two day intervals until the clutch is complete (Connelly et al. 1998). Females may lay eggs anytime during the day, but most commonly, they lay during late morning to mid-afternoon. The female often covers the eggs after laying. Hart et al. (1950) described the eggs of the Columbian subspecies as being an irregular olive color with a slight amount of pale blue showing through, and with a light, variable speckling of dark chocolate brown. The color of the eggs fades as the incubation period progresses. Eggs of the southern forms of the sharp-tailed grouse tend to be lighter than those of the northern forms (Bendire 1892). Average dimensions (length X width) of the eggs range from 42.5 to 44.5 mm X 30.9 to 34.0 mm (Connelly et al. 1998).

Incubation is entirely by the female and does not begin until the last egg is deposited (Connelly et al. 1998). The female usually leaves the nest to feed for approximately 30 to 45 minutes in the morning and again in the evening (Hart et al. 1950). Unlike during the laying period, the female does not cover the eggs when leaving for an incubation break.

Sharp-tailed grouse may renest if the first nest is destroyed or abandoned due to disturbance (Connelly et al. 1998). Not all females that lose or abandon their first clutch will attempt to renest. The renesting rate (proportion of females that survived an initial nest failure that attempted to renest) varies with age. The likelihood of renesting is greater if the first clutch is lost or abandoned during the laying period or early in the incubation process. The longer a female incubates her first clutch before it is lost or abandoned, the less likely she will attempt to renest. Females that attempt to renest will revisit the lek to mate and initiate the second clutch with 10 to 14 days of losing the first clutch. Females may renest more than once, but multiple renest attempts in Region 2 are unusual.

Giesen (1997) reported that 92 percent of the CSTG females he monitored nested within 2.0 km (median = 1.4 km) of their lek of capture. Similarly, Meints (1991), Apa (1998), and McDonald (1998) all reported average movements to nests of less than 2.0 km. Boisvert et al. (2005) documented a median movement to nest sites of 0.63 km (range = 0.09–11.30 km) for 58 CSTG females in northwestern Colorado; 86 percent of all females in this study nested within 2.0 km of their lek of capture. In another Colorado study, Collins (2004) recorded 130 movements from lek of capture to initial nest sites. The median movement was 0.98 km (range = 0.15–21.75 km), with 82 percent of all females nesting within 2.0 km of their lek of capture. Collins (2004) also found that 94 percent of 18

movements (median = 0.76 km, range = 0.16–3.71 km) to renest sites were within 2.0 km of the lek of capture, and that median movement between initial and renest sites was 0.54 km (n = 18, range = 0.20–3.47).

Recent studies indicate that female CSTG not only exhibit fidelity to leks, but also to nesting areas between years. Six females monitored by Boisvert et al. (2005) over two consecutive nesting seasons nested within 250 m of their previous years' nests. The median distance between successive nest sites for 28 females monitored by Collins (2004) was 310 m (range = 20–5,270 m), with 85 percent nesting within 400 m of their previous years' nest. Collins (2004) was able to follow two females through three nesting seasons. These females selected initial nest sites in three consecutive years that were within 9 and 190 m of each other.

Summer/brood-rearing season

By mid- to late June, males are visiting and spending less time on leks, but they continue to show fidelity to areas near the lek. Boisvert et al. (2005) reported that 96 percent of 23 radio-marked males remained within 2.0 km of the lek where they were captured throughout the summer. The median summer movement from lek of capture was only 400 m. In the same study, 41 unsuccessful females (females that fail to hatch a clutch of eggs) moved farther (median = 840 m) from their lek of capture during summer than males, but 71 percent still remained within 2.0 km of their lek of capture (Boisvert et al. 2005). Collins (2004) reported longer median movements (males = 1,140 m, females = 2,700 m) from leks of capture during summer than Boisvert et al. (2005). Collins (2004) attributed the longer movements in part to the drought conditions that prevailed during the two years of his study.

Males continue to associate in flocks during summer. Flock size can vary from only a few individuals to 10 to 15 birds. Some males may leave the flocks and be alone for a period of time. Unsuccessful females also associate in flocks during summer, but they tend to associate in smaller groups (two to five birds), and they are more commonly found alone than males are. There appears to be no social organization or continuity within flocks. An individual may be found alone one day and part of a flock the next. Even within the same day, an individual may be alone part of the day and associated with a flock at other times.

While males occasionally visit leks during summer, females do not. When males do visit leks in summer, they are only there for a short period of time. They most often just sit on the lek and only briefly engage in any display activity. Both males and females use the same general summering areas year after year unless drought conditions cause them to move elsewhere. In normal and above average precipitation years, they continue to use the shrubsteppe zone during the summer. In drier years, they may move into the mountain shrub zone. Collins (2004) documented this behavior for CSTG breeding in northwestern Colorado during the severe drought year of 2002.

Females and young abandon the nest site soon after the last egg hatches. Newly hatched young are precocial, meaning they are fully-feathered and capable of walking and foraging on their own. They require regular brooding by females during the first two weeks of life and less frequent brooding as they get older. By three weeks of age, they can regulate their own body temperature and no longer require brooding.

Median movements from nest sites to brood-rearing areas have been reported as 400 (n = 25, Boisvert et al. 2005) and 780 m (n = 54, Collins 2004) and range from 100 m to nearly 6.0 km. Approximately 78 percent of the successful females in these two studies raised their broods within 1 km of where they nested. This indicates that females select nest sites within or immediately adjacent to suitable brood habitat. In the study conducted by Collins (2004), four successful females made unusually long (>3.5 km) movements to brood-rearing areas. Three of the four long movements were made during the severe drought year of 2002. Excluding these longer movement, movements from nest to brood-rearing areas documented by Collins (2004) are nearly identical to those reported by Boisvert et al. (2005).

During summer, CSTG forage during the cooler parts of the day and rest in the shade during mid-day. Marks and Marks (1987) found no evidence that CSTG sought free water during summer. The mean daily movement from time of hatch until 1 August for 17 broods monitored by Meints (1991) in southeastern Idaho was 58 ± 17 m. Chicks are capable of short flights at 7 to 10 days of age, but they usually walk and generally freeze in place or run and hide when disturbed (Hart et al. 1950). When a brood is disturbed, the hen will fake injury in an attempt to distract and lead the intruder away (Hart et al. 1950). The younger the brood, the closer the hen can be approached before she moves and tries to distract the intruder. As the brood gets older, the hen is more likely to flush without performing any distraction behavior. Even as the flying ability of juveniles improves, they prefer to hide or

sit tight rather than flush until their flying abilities approach those of adults.

Males, successful females and their broods, and unsuccessful females use the same general areas during summer but seldom associate in the same flocks. Later in summer, individual broods may combine to form gang broods. By late August, it is not uncommon to observe different age classes of chicks accompanied by two or more females. Brood dispersal begins in late summer (late August–early September). Brood dispersal is a gradual process, with individual broods separating at different times and individuals within a brood leaving at different times.

Fall season

Brood dispersal continues into the fall period. In mid- to late September, males start to attend leks on a regular basis (**Table 5**). Not all leks active in spring are active in fall (R.W. Hoffman personal observation). This is mainly true for smaller (<10 males) leks, but also has been noted for leks with over 20 males during the spring (R.W. Hoffman personal observation). Efforts directed at trapping CSTG on leks in the fall indicate that some females visit the leks at this time. Of 98 CSTG trapped on leks during fall in northwestern Colorado, 14 (four adults, 10 juveniles) were females and 84 (65 adults, 19 juveniles) were males (Boisvert 2002, Collins 2004).

Fall lek attendance may serve several functions:

❖ allow adult males to reaffirm or possibly improve their position on the lek

❖ provide juvenile males and juvenile females an opportunity to learn where leks occur

❖ allow some juvenile males the opportunity to establish themselves as peripheral males.

It appears as if adult females are occasionally attracted to the leks in fall possibly out of social curiosity (i.e., presence of other grouse) more so than for any other reason. Although males display to females, they do not attempt to copulate with them (R.W. Hoffman personal observation). In some cases, males treat juvenile females as if they are males, often chasing them off the lek. Males in fall do not react to the presence of females on leks with the same intensity as they do in spring. By far, the majority of activity on leks in fall appears to be aggressive activity directed at other males.

Flocking tendencies of sharp-tailed grouse during fall are highly variable. They may occur singly, in small groups of two to 10 birds, and in large flocks exceeding 30 birds. The mean number of grouse observed per observation ($n = 14$) in south-central Wyoming during the fall period was 7.1, and the maximum flock size was 30 individuals (Oedekoven 1985). Flock counts obtained during late fall in northwestern Colorado averaged 14.9 grouse (Hoffman 1980). Of 21 encounters, 18 were with flocks varying from two to 101 individuals, and three (14 percent) were of lone birds (Hoffman 1980). In Utah, average flock sizes ranged from 12.7 to 32.3 grouse per flock in late fall (late October to early December). Despite the wide variation in flock sizes during fall, overall, flock sizes tend to be greatest at this time of year (Hart et al. 1950). Larger flocks are often the result of the grouse concentrating near areas of abundant food, such as along the edge of harvested wheat fields. These larger flocks have no definite organization, may disband during the day, and frequently vary in number from one day to the next (Hart et al. 1950).

Boisvert et al. (2005) documented that no radio-marked grouse in 1999 left the spring-fall range until 14 November. In fall 2000, movements from the spring-fall range started in late October, and 84 percent of the radio-marked birds were on wintering areas by mid-November (Boisvert et al. 2005). The earlier departure in 2000 compared to 1999 was likely due to the earlier onset of winter conditions in 2000. Regardless of when grouse started to leave the spring-fall range, in both years, females departed before the males (Boisvert et al. 2005). Kobriger (1965) and Gratson (1988), along with Boisvert (2002), attributed the later departure of males in fall and their subsequent earlier return in the spring to their greater attachment to lek sites.

Winter season

When herbaceous vegetation and agricultural crops become snow covered, CSTG move to riparian zones and patches of mountain shrubs (Marks and Marks 1988, Schneider 1994, Ulliman 1995b, McDonald 1998, Boisvert 2002). This usually happens by mid-December (**Table 5**). Areas used for wintering are often spatially distinct from areas used for breeding, nesting, and brood-rearing (Marks and Marks 1988, Meints 1991, Collins 2004, Boisvert et al. 2005). In mild winters, CSTG may continue to use open grassland, including Conservation Reserve Program (CRP) and agricultural lands, and shrubsteppe cover types (Ulliman 1995b, McDonald 1998), or they may move between the

mountain shrub and more open cover types depending on snow conditions. This rarely happens in Region 2 because snow covers most of the spring-fall range from mid-December through mid- to late March. Thus, during most winters in Region 2, there is a distinct movement of CSTG from the spring-fall range to wintering areas (Oedekoven 1985, Giesen 1997, Collins 2004, Boisvert et al. 2005).

Distances moved between spring-fall and winter ranges can vary from less than 0.5 km to greater than 40 km (**Table 6**). Boisvert et al. (2005) found no differences in movements to wintering areas between males (median = 21.5 km, range = 4.2–36.5 km, n = 13) and females (median = 21.4 km, range = 3.1–41.5 km, n = 17) or between CSTG breeding in CRP (median = 21.5 km, range = 3.4–36.5 km, n =5) and mine reclamation lands (median = 21.4 km, range = 4.2–41.5 km, n = 25). In contrast, Collins (2004) documented significantly longer movements to wintering areas for females breeding in shrubsteppe (median = 5.9 km, range = 0.5–42.5 km, n = 38) and mine reclamation (median = 8.6 km, range = 1.3–48.9 km, n = 33) compared to males breeding in shrubsteppe (median = 2.0 km, range = 0.5–8.9 km, n = 10) and mine reclamation (median = 6.9 km, range = 0.5–28.6 km, n = 37).

The literature is unclear whether males typically remain closer to leks during winter than females do. McDonald (1998) reported females moving farther to wintering areas than males on one study area, whereas the opposite was documented on another study area. Ulliman (1995b) found that males remained closer to leks than females during both years of his study. The studies by McDonald (1998) and Ulliman (1995b) had small sample sizes (**Table 6**) and may not be indicative of the populations they studied. Boisvert et al. (2005) found that males and females moved similar distances to wintering areas, but this study also had a small sample size of males (**Table 6**). Collins (2004) documented the largest number of movements to wintering areas by CSTG (**Table 6**). Although data from this study indicated that females moved farther than males to wintering areas, some males also moved long (>20 km) distances, and some females wintered close (<2 km) to their lek of capture.

Ulliman (1995b) hypothesized, and McDonald (1998) concurred, that females move farther to wintering areas than males do to avoid harassment and competition for food near leks. This implies at least partial gender segregation during winter. Collins (2004) and Boisvert et al. (2005) found limited evidence to

Table 6. Distances (km) moved by Columbian sharp-tailed grouse from their lek of capture to wintering areas.

Gender	n	Median	Mean	Range	Location	Reference
Male	13	21.5	20.0	4.2–36.5	Colorado	Boisvert et al. 2005
Female	17	21.4	22.1	3.1–41.5	Colorado	Boisvert et al. 2005
Male	47	5.4	6.5	0.5–28.6	Colorado	Collins 2004
Female	71	7.5	10.4	0.5–48.9	Colorado	Collins 2004
Male	3	1.1	—	0.7–1.5	Colorado	Giesen 1997
Female	1	6.7	—	—	Colorado	Giesen 1997
Male	9	—	2.8	0.8–9.7	Washington	McDonald 1998
Female	4	—	2.3	1.1–4.3	Washington	McDonald 1998
Male	2	—	1.0	0.2–2.6	Washington	McDonald 1998
Female	6	—	5.5	0.5–11.5	Washington	McDonald 1998
Male	6	0.6	—	0.5–2.2	Idaho	Ulliman 1995b
Female	6	3.2	—	1.1–9.9	Idaho	Ulliman 1995b
Male	4	2.0	—	1.2–3.7	Idaho	Ulliman 1995b
Female	9	3.4	—	0.8–9.2	Idaho	Ulliman 1995b

support this hypothesis. First, neither Collins (2004) nor Boisvert et al. (2005) found that males necessarily wintered in the closest suitable habitat to their lek of capture. Boisvert et al. (2005) reported that no radio-marked grouse (male or female) wintered within 3 km of their lek of capture even though suitable winter habitat occurred within 2 km of all the leks trapped in their study. Second, both Collins (2004) and Boisvert et al. (2005) documented males and females wintering in the same geographic area. Collins (2004) also documented males and females captured on the same lek wintering in the same general area. It is possible, as noted by Collins (2004), that females using the same general area as males may segregate from males on a finer scale than studies have documented to date.

Giesen and Connelly (1993:327) stated, "Columbian sharp-tailed grouse seem to move farther to wintering habitats in regions lacking a broad distribution of winter food resources." Results of studies within Region 2 in northwestern Colorado contradict this statement (Collins 2004, Boisvert et al. 2005). Northwestern Colorado and south-central Wyoming have not experienced large-scale habitat conversions that have occurred in many other areas within the range of CSTG (Ritcey 1995, McDonald and Reese 1998, Schroeder et al. 2000, Utah Division of Wildlife Resources 2002). Consequently, landscapes, and particularly the mountain shrub and quaking aspen (*Populus tremuloides*) cover types used for winter habitat (Boisvert 2002), have remained relatively intact, comprising greater than 20 percent of the available cover types in this area (Hoffman 2001). Despite the abundance of winter habitat near leks, some grouse still moved long distances to wintering areas (Collins 2004, Boisvert et al. 2005).

Boisvert et al. (2005) speculated that CSTG may disperse throughout the available winter range rather than concentrate in the nearest suitable winter habitat in relation to where they breed to reduce their vulnerability to predators. During the winter, CSTG feed in the upper branches of tall deciduous shrubs (Schneider 1994) where they are exposed and possibly more susceptible to avian predators. Furthermore, there is little or no hiding cover at ground level at this time of year because of snow conditions. Large concentrations of grouse in this situation may attract predators and increase their mortality rates. Conversely, if they are dispersed throughout the available winter range, their chances of survival may be greater. For this to be true, the survival advantage gained by this behavior must outweigh the increased risk of moving long distances.

Hamerstrom and Hamerstrom (1951) suggested that long distance movements were historically common for plains and prairie sharp-tailed grouse under pristine conditions. If this is also true for CSTG, then longer movements should not be interpreted as indicative of areas having low suitability for sharp-tailed grouse as implied by Giesen and Connelly (1993).

Boisvert et al. (2005) suggested that CSTG breeding in non-native cover types, such as CRP and mine reclamation lands, may move farther to wintering areas than those breeding in native shrubsteppe. This may be due to the attractiveness of CRP and mine reclamation lands as lek sites. Conservation Reserve Program and mine reclamation lands account for only 4 percent of the occupied range of CSTG in northwestern Colorado, but they support about 44 percent of the known active leks (Hoffman 2001). It appears that CSTG will move longer distances between breeding and winter ranges to use this limited resource. In support of this contention, Collins (2004) documented that male (median = 6.9 km, range = 0.5–28.6 km, n = 37) and female (median = 8.6 km, range = 1.3–48.9 km, n = 33) CSTG captured on leks in mine reclamation traveled significantly longer distances to and from wintering areas than their counterparts captured on leks in native shrubsteppe (male: median = 2.0 km, range = 0.5–8.9 km, n = 10; female: median = 5.9 km, range = 0.5–42.5 km, n = 38).

Once on winter range, CSTG are relatively sedentary. Median daily movements of CSTG during winter in southeastern Idaho were 221 and 286 m for females and males, respectively (Ulliman 1995b). Fidelity of CSTG to wintering areas is poorly understood. Based on the few CSTG followed during successive winters, most returned to the same general area where they wintered the previous year (Collins 2004, Boisvert et al. 2005). Also, CSTG captured on the same leks in successive springs moved to the same general wintering areas (Collins 2004, Boisvert et al. 2005), suggesting that CSTG from the same breeding population use the same traditional wintering areas year after year. Boisvert et al. (2005) found that, although suitable winter habitat occurred in all directions from where CSTG were captured, movements to wintering areas were nonrandom, further suggesting that CSTG use traditional wintering areas. Finally, in searching for and locating CSTG during winter, Boisvert et al. (2005) and Collins (2004) discovered that large expanses of apparently suitable winter habitat were devoid of grouse and that they consistently found CSTG in the same areas each winter.

Snow roosting is an adaptation for staying warm, conserving energy, and remaining inconspicuous. Columbian sharp-tailed grouse roost beneath the surface of the snow at night during winter when snow conditions are suitable (Hart et al. 1950, Marks and Marks 1987, McDonald 1998). They also commonly roost beneath the snow during the day when they are not feeding. During severe winter weather and low temperatures, sharp-tailed grouse remain in their burrows through the night and may emerge only once during the day to feed (Gratson 1988). Columbian sharp-tailed grouse snow roost in small openings within and immediately adjacent to patches of shrubs, but they seldom roost within the shrub patches (Odekoven 1985, Marks and Marks 1987, McDonald 1998). This may be because soft snow suitable for roosting accumulates around the edges of shrub patches, creating optimal burrowing conditions.

Other subspecies of sharp-tailed grouse may roost in trees during the day and at night when snow conditions are not suitable for snow roosting (Gratson 1988). This behavior has been rarely reported for CSTG. Although CSTG may perch in trees to feed or when flushed from the ground, they seldom roost there. The only study that mentions CSTG roosting in trees at night during winter is Hart et al. (1950:38), who stated "when the snow is crusted, and occasionally at other times, the birds pass the night on low limbs of shrubs and trees." Marshall and Jensen (1937) reported that CSTG roosted in bushes (but not trees) protruding above the snow during winter because of the snow being crusted.

Columbian sharp-tailed grouse in eastern Washington burrowed in the snow when depths exceeded 28 cm and the surface was not crusted (McDonald 1998). Prairie sharp-tailed grouse in Wisconsin snow burrowed when snow depths exceeded 18 cm (Gratson 1988). The average length of snow burrows in eastern Washington was 73 ± 12 cm (range = 28–180 cm). Gratson (1988) reported that night burrows (mean = 240 ± 50 cm) were longer than daytime burrows (mean = 140 ± 70 cm). Neither investigator provided data on depth of snow burrows. However, because the submerged grouse may need to escape quickly, they likely do not burrow very deep. The average depth of a night roost for white-tailed ptarmigan (*Lagopus leucura*) is 160 mm (range = 90–270 mm) with about 30 to 50 mm of snow covering the submerged bird (Braun and Schmidt 1971). Since sharp-tailed grouse are larger than ptarmigan, their burrows should be slightly deeper, but the amount of snow above the bird is probably about the same. Sharp-tailed grouse do not plunge into the snow like ruffed grouse (*Bonasa umbellus*; Runkles and

Thompson 1989). Instead, they dig, push, wiggle, and tunnel their way beneath the snow. Occasionally, when snow roosting during the day, they will stick their head above the snow surface.

Boisvert et al. (2005) noted a positive elevation gain (median = 102 m, range = 5–383 m) associated with movements from spring-fall to winter ranges. Collins (2004) also mentions movements to higher elevations during winter but did not quantify this information. Two possible reasons why CSTG move up in winter are (1) moisture conditions at higher elevations are more conducive to supporting tall deciduous shrubs required during winter, and (2) snow conditions are better (i.e., deeper and softer snow) for roosting

Flocking may be advantageous for sharing or obtaining information on food distribution and for predator detection, both of which may increase survival of individual flock members. At no time are the flocking tendencies of sharp-tailed grouse more evident than during winter when food availability and hiding cover are most limited due to snow accumulation. Sharp-tailed grouse are less likely to be observed alone during winter than at any other time of the year, with the exception of females during the nesting season. Of 56 encounters of CSTG during winter in northwestern Colorado reported by Boisvert (2002), only 9 percent were of lone birds and 91 percent were of flocks containing two to 30 individuals (mean = 6.9, median = 5.5). Thirty-five winter flocks encountered in south-central Wyoming averaged only 3.7 grouse (Oedekoven 1985). Average mid-winter (January and February) flock sizes in Utah ranged from 4.9 to 8.3 grouse (Hart et al. 1950). In western Idaho, winter flock size ($n = 88$) averaged 5.6 ± 6.4 grouse; the largest flock contained 32 grouse (Marks and Marks 1987). In southeastern Idaho, Meints (1991) reported average winter flock sizes of 22 ± 44 ($n = 36$) and 5 ± 3 ($n = 32$) grouse in two different areas. The larger flock size occurred in an area where CSTG concentrated in grain fields to feed and moved to mountain shrub habitats during the day. No grain fields occurred in the area where the smaller flocks were found.

Hart et al. (1950) and Gratson (1988) reported that flock sizes of sharp-tailed grouse are largest during early winter and decrease in size as the winter progresses and snow cover increases. This is contrary to the prediction that grouse should join flocks when food availability decreases. Gratson (1988) found that flocking tendencies of sharp-tailed grouse in Wisconsin were related to snow burrowing opportunities more than food availability. At snow depths that allowed grouse to

snow burrow, birds associated in smaller flocks. When snow was insufficient for burrowing and the birds had to roost exposed on the surface of the snow, smaller flocks joined to form larger flocks. These data are consistent with the hypothesis that grouse join flocks when they are most conspicuous. When grouse can snow burrow, they are conspicuous only when feeding; thus, the need for increased vigilance owing to flocking is less (Gratson 1988).

Habitat

General

At the ecosystem level, CSTG inhabit the Temperate Semi-desert, Temperate Dry Steppe, and Temperate Steppe Mountain ecoregions of the United States (Bailey 1995, 1998). These regions receive an average of 5 to 50 cm of precipitation per year, much of which falls as snow during winter. Mean summer temperatures range from 10 to 34 °C, and winter temperatures range from −14 to 8 °C. The terrain is diverse, varying from broad, relatively flat expanses to gentle rolling hills and low mesas to steep, mountainous slopes. The vegetation types growing within the different ecoregions are equally diverse due to topography, soils, moisture conditions, elevation, and aspect.

Columbian sharp-tailed grouse prefer to use moderate terrain (slopes ≤ 10 to 20°; Marks and Marks 1987) and associated vegetation types, except during winter when they may use vegetation types on steeper slopes. They have a decided preference for habitat edges in native cover types. Areas with a mosaic of cover types are preferred over large continuous patches of uniform cover. Depending on the geographic area, elevations where CSTG occur can range from less than 500 m to more than 2,500 m. Native vegetation types associated with the presence of CSTG are sagebrush steppe (*Artemisia-Agropyron*), shrubsteppe (*Artemisia-Symphoricarpos-Amelanchier-Prunus-Purshia-Agropyron*), mountain mahogany-oak shrub (*Cercocarpus-Quercus*), fescue-wheatgrass (*Festuca-Agropyron*), wheatgrass-bluegrass (*Agropyron-Poa*), aspen-shrub (*Populus tremuloides-Amelanchier-Prunus*), mountain shrub (*Amelanchier-Prunus-Quercus* or *Acer-Amelanchier*), hawthorn (*Crataegus* spp.), juniper-shrub (*Juniperus-Artemisia-Amelanchier*), and riparian (*Salix-Betula-Alnus*).

Columbian sharp-tailed grouse may use a variety of plant communities to meet their seasonal habitat needs. Studies have shown that they typically occupy grass-low shrub (<1 m) dominated communities during spring, summer, and fall, and tall shrub (>1 m) cover types during winter (Marshall and Jensen 1937, Hart et al. 1950, Marks and Marks 1987, Ulliman 1995b, Giesen 1997, Apa 1998, McDonald 1998, Boisvert 2002, Collins 2004). Shrubs are a critical component of winter habitat. Columbian sharp-tailed grouse show greater flexibility in the proportion of shrubs that comprise use areas at other times of the year. During spring through fall, CSTG use grasslands with little or no shrubs in the composition as well as shrub-grass cover types with up to 40 percent shrub cover. The key factor is the amount of cover provided by the vegetation more than the actual species composition. Whether it is a shrub- or grass-dominated landscape, a certain height and density of vegetation is required. The growth form of the grass component also appears to be an important cover consideration, with bunchgrasses providing better cover than sod-forming grasses.

The CSTG is a habitat generalist and can adapt to moderate alterations in the native landscape. For example, CSTG may continue to use sagebrush rangelands that have been sprayed or burned and reseeded with non-native grasses, provided adequate cover remains. Columbian sharp-tailed grouse also can use and, in some cases, thrive in artificially-created cover types. For instance, CSTG may use cultivated croplands, such as wheat (*Triticum* spp.) and alfalfa (*Medicago sativa*), at certain times of the year (Hart et al. 1950, McDonald 1998). Croplands must occur in close proximity to permanent cover that provides nesting, brood-rearing, and winter habitat to benefit CSTG. Large blocks of agricultural lands will not support sharp-tailed grouse. More recently, CSTG have been documented using CRP and mine reclamation lands (Sirotnak et al. 1991, Ulliman 1995b, Apa 1998, McDonald 1998, Hoffman 2001, Boisvert 2002, Collins 2004). Conservation Reserve Program and mine reclamation lands (**Figure 5**) have been associated with increases in CSTG populations in Utah, Idaho, and Colorado (Ulliman et al. 1998, Hoffman 2001, Utah Division of Wildlife Resources 2002).

Even though CSTG select habitats predominantly based on structural characteristics of the vegetation and secondarily on species composition, this does not negate the significance of certain plant species. Common native plants found throughout the range of CSTG in the western United States that have been identified as being important for cover and/or food include big sagebrush, Saskatoon serviceberry (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), hawthorn, water birch (*Betula occidentalis*), bluebunch wheatgrass (*Pseudoroegneria spicata*), western wheatgrass

Figure 5. Conservation Reserve Program (top) and mine reclamation lands (bottom) bordering native shrubsteppe and mountain shrub communities provide ideal breeding, nesting, and brood-rearing habitats for Columbian sharp-tailed grouse in northwestern Colorado. Photographs by Richard W. Hoffman.

(*Pascopyrum smithii*), basin wildrye (*Leymus cinereus*), Idaho fescue (*Festuca idahoensis*), Sandberg bluegrass (*Poa secunda*), arrowleaf balsamroot (*Balsamorhiza sagittata*), buckwheat (*Eriogonum* spp), hawksbeard (*Crepis* spp.), hawkweed (*Hieracium* spp.), lupine (*Lupinus* spp.), knotweed (*Polygonum* spp.), and pale agroseris (*Agroseris glauca*). Non-native plants frequently associated with CSTG habitats include alfalfa, common dandelion (*Taraxacum officinale*), yellow salsify (*Tragapogon dubius*), and prickly lettuce (*Lactuca serriola*).

In Region 2, CSTG occur in the transition zone between the arid sagebrush rangelands and the start of the aspen-conifer forests at elevations ranging from 1,890 to 2,591 m (Oedekoven 1985, Hoffman 2001).

This is the highest elevation at which CSTG occur throughout their current range. Climatic conditions vary from semi-arid to continental. Large diurnal and seasonal temperature changes occur throughout the region. Average annual precipitation ranges from less than 25 cm at Craig, Colorado to 31 cm at Dixon, Wyoming to 127 cm near Steamboat Springs, Colorado. Most precipitation falls as snow from November through March and as snow or rain during April and May. Daily temperatures in summer range from 4 to 33 °C. Maximum daytime temperatures during winter range from −12 to 4 °C. The average annual temperature varies from 4.6 to 5.4 °C depending on location. Freezing temperatures are likely during some part of the day from October through April.

The natural progression of vegetation types is from sagebrush-grass to shrubsteppe to mountain shrub to aspen to aspen-conifer to conifer. Small aspen patches are commonly scattered throughout the mountain shrub type. Narrow-leafed cottonwood (*Populus angustifolia*) grows along the rivers and many of the larger creek bottoms; adjacent areas have been largely converted to grass-hay meadows, alfalfa, pastureland, or wheat (Colorado only). Wheat fields and pasture lands also extend into the uplands within the shrubsteppe and mountain shrub types. Many wheat fields in the upland sites are currently enrolled or were formerly enrolled in the CRP. These fields primarily support stands of non-native grasses, such as smooth brome (*Bromus inermis*) and intermediate wheatgrass (*Thinopyrum intermedium*). Reclaimed coal mine lands are a minor but important part of the landscape in northwestern Colorado (Hoffman 2001, Boisvert 2002, Collins 2004). Mine reclamation lands occur mainly within the shrubsteppe and mountain shrub vegetation types, but they may extend into the sagebrush-grass and aspen types. Mine reclamation lands resemble CRP lands but contain a greater diversity of native and non-native grasses and forbs compared to CRP (Boisvert 2002). Further, mine reclamation lands may include a shrub component depending on the original seed mixture, planting method, and growing conditions (Boisvert 2002, Collins 2004).

Breeding habitat

Columbian sharp-tailed grouse leks are typically positioned on elevated sites in open areas where the vegetation is short and sparse (Hart et al. 1950, Rogers 1969, Parker 1970, Ward 1984, Boisvert 2002). The actual lek site is usually flat. Data collected by the CDOW in northwestern Colorado revealed that 83 percent of 141 leks occurred on elevated sites, such as knolls, ridges, or benches, where the slope was 2 percent or less (**Table 7**). Seven of nine lek sites in south-central Wyoming described by Oedekoven (1985) were in small, grassy openings on relatively flat terrain surrounded by mixed shrub or sagebrush cover. The average slope at lek sites in south-central Wyoming was 4 ± 3 percent (Klott and Lindzey 1989). Of 52 lek sites classified by Hart et al. (1950) in Utah, 32 were on hills with a definite elevation advantage over the surrounding area, and 20 were on flats with only a slight but obvious elevation advantage over the surrounding area. Four of five leks in southeastern Idaho described by Ward (1984) were along low ridges and one was on a flat; the average slope was 2 percent.

Boisvert (2002) measured seven macrohabitat variables at 16 lek sites in CRP and mine reclamation and found that topographic location was the only variable that was significantly different between lek and random sites. Of 12 microhabitat variables measured at the same lek and random sites, five were different (Boisvert 2002). Lek sites tended to have lower species richness, slightly less grass cover, substantially less shrub cover, more bare ground, and lower visual obstruction readings than random sites did.

Visibility and audibility are key features affecting where leks are situated (Wiley 1978, Ward 1984). Elevated sites promote attraction of females to leks by maximizing the sound transmission of males (Baydack 1988). Sparse vegetation on the lek further promotes attraction of females to the lek by not muffling the sounds of males. The openness of the lek also allows for greater visibility to detect predators, facilitates the ritualized displays of males, promotes easier movements on the lek, and provides females an unrestricted view of males on the lek.

Columbian sharp-tailed grouse appear to tolerate a greater range of cover and greater amounts of cover (especially shrubs) on the lek than other subspecies of sharp-tailed grouse and other species of prairie grouse do. In southwestern Manitoba, lek sites of prairie sharp-tailed grouse supported less than 1 percent shrub cover (Baydack 1988). Shrub cover at five CSTG leks in southeastern Idaho averaged 7 percent (Ward 1984). Shrub cover at CSTG leks in native vegetation types in south-central Wyoming averaged 11.1 ± 7.4 percent (Klott and Lindzey 1989). Shrub cover at leks in CRP and mine reclamation in northwestern Colorado did not exceed 1.5 percent (Boisvert 2002). Columbian sharp-tailed grouse leks in south-central Wyoming had greater

Table 7. Characteristics of Columbian sharp-tailed grouse lek sites in northwestern Colorado based on data collected by the Colorado Division of Wildlife.

Characteristic	*n*	Percent
Cover type		
Sagebrush[1]	87	35
Conservation Reserve Program	53	21
Grass hay-pasture	49	20
Mine reclamation	36	15
Native grass	12	5
Agriculture[2]	8	3
Mountain shrub	2	1
Nearest cover type		
Sagebrush[1]	68	48
Mountain shrub	62	37
Aspen-shrub	8	6
Native grass	5	4
Grass hay-pasture	3	2
Agriculture	2	1
Conservation Reserve Program	1	<1
Mine reclamation	1	<1
Riparian-cattail marsh	1	<1
Topographic location		
Knoll	45	32
Ridge	44	31
Bench	28	20
Flat	16	11
Slope	8	6
Aspect		
North	38	30
East	26	20
South	16	13
West	25	20
None	22	17
Slope (%)		
0–2	107	76
3–5	28	20
6–9	6	4
≥ 10	0	0

[1]Includes sagebrush-grass and shrubsteppe.

[2]Includes wheat and alfalfa.

shrub cover, taller shrubs, and greater numbers of shrub, forb, and grass species than greater sage-grouse leks did (Klott and Lindzey 1989). In addition, CSTG leks were typically at higher elevations and situated at the edge more so than in the middle of openings compared to greater sage-grouse leks. Visibility, as measured with a cover board (Jones 1968), was greater at sage- and sharp-tailed grouse leks than at random sites, with visibility being greatest at sage-grouse leks.

The amount of cover on the lek appears to be a trade-off between high visibility desirable for breeding and displaying, and lower visibility that enhances security (Klott and Lindzey 1989). Ward (1984) found that male CSTG used the more open areas of their territories on the lek when females were present, but they stayed in areas of greater cover when females were absent. The females tended to use areas with more cover as they moved across the lek. If shrubs are present on the lek, males will use them as perches and calling posts to increase their own audibility and visibility to females. Males also will perch on shrubs when females are absent. This behavior may improve their ability to detect predators.

The actual cover type at the lek is less important than the growth form. Columbian sharp-tailed grouse leks have been found in native shrub and grassland cover types as well as non-native and artificial cover types, including CRP, mine reclamation, pastureland, wheat fields, alfalfa fields, and grass hay meadows (**Table 7**). Within a particular vegetation type, CSTG select sites for leks that offer high visibility, but visibility may vary substantially among leks in different cover types. For example, a lek in shrubsteppe will likely have higher visual obstruction readings (i.e., lower visibility) than a lek in CRP or native grassland.

Other important features influencing where leks occur include food availability and juxtaposition of suitable escape and loafing cover. In some areas where CSTG breed, much of the landscape is snow covered when males return to the breeding range in spring. Nowhere is this more evident than in portions of Region 2 where elevations at lek sites average 2,171 ± 121 m (median = 2,174 m) in Colorado and 2,814 ± 79 m in Wyoming (Klott and Lindzey 1989, Lassige 2002). Oedekoven (1985) reported that CSTG in south-central Wyoming began courtship displays in mid-April when snow depths were 50 to 100 cm. In this situation, CSTG must rely on shrub communities for food and cover during the early part of the breeding season when the herbaceous vegetation is snow covered or has not started to grow (Boisvert 2002). At this time of year, even the exposed, residual, herbaceous vegetation affords little cover because it has been flattened by winter snow. Therefore, during early spring (late March to late April), availability of shrub-dominated communities near (≤ 400 m) leks is critical for food, escape cover, and loafing cover. Edge density of shrubsteppe was one of four variables consistently associated with lek sites at multiple spatial scales in northwestern Colorado (Lassige 2002). Boisvert (2002) documented substantial use of shrubsteppe cover types in spring by CSTG

attending leks in CRP and mine reclamation lands in northwestern Colorado. Shrub-dominated cover types occurred on average 127 m (range = 15–450 m) from the center of the leks monitored by Boisvert (2002). Invariably, when the grouse were disturbed on leks, they flew to the nearest patch of shrubs. Boisvert (2002) concluded that although CRP and mine reclamation lands provided ideal sites for leks, CRP, and to a lesser extent mine reclamation, did not provide adequate cover for concealment when CSTG were not on the leks until later in spring after the herbaceous vegetation started to grow.

Perhaps the single most important factor affecting lek location is the proximity to suitable nesting-brooding rearing cover (Meints et al. 1992). Studies in Region 2 indicate that greater than 80 percent of all females nest and raise their young within 2 km of their lek of capture (Oedekoven 1985, Giesen 1997, Collins 2004, Boisvert et al. 2005). Thus, availability of elevated, sparsely vegetated sites is only relevant if suitable nesting and brood rearing cover occurs nearby. The actual lek site is less important than quality and quantity of cover surrounding the lek.

Nesting habitat

Columbian sharp-tailed grouse are nest habitat generalists and nest in many different cover types (Apa 1998). Specific features of CSTG nest sites vary among studies because of geographic differences in cover types available for nesting, differences in growing conditions, variations in sampling methodology, and timing of measurements in relation to nest initiation. Regardless, nests tend to be in vegetation types that provide dense vertical and horizontal concealment (Meints et al. 1992, Giesen and Connelly 1993, Tirhi 1995). The composition and condition (live or dead) of the vegetation at the nest are less important than its structure and growth form. For this reason, CSTG have been documented nesting in undisturbed and disturbed (sprayed or burned) native cover types as well as non-native and artificial cover types. Columbian sharp-tailed grouse also show a high degree of flexibility in the proportion of grasses, forbs, and shrubs that comprise suitable nesting cover. They may nest in grasslands, croplands, seeded rangelands, CRP lands, and mine reclamation with little or no shrubs in the plant community, or they may nest in sagebrush-grass, shrubsteppe, and mountain shrub communities with up to 40 percent shrub cover (Hart et al. 1950, Marks and Marks 1987, Meints 1991, Schroeder 1994, Giesen 1997, Apa 1998, McDonald 1998, Boisvert 2002, Collins 2004). The common denominator appears to be the amount of cover provided by the vegetation

whether it is herbaceous, shrubs, or a combination of both. That is, a certain height and density of vegetation is required for nesting regardless of its composition.

Of 127 nest sites found in north-central Utah, 53 percent were in alfalfa, 27 percent in wheat stubble, and only 18 percent in native vegetation (Hart et al. 1950). This was attributed to the general lack of native vegetation across the landscape and its poor condition due to overgrazing. In west-central Idaho, Marks and Marks (1987) found nine nests, all of which were in native cover, including eight in sagebrush cover types and one in mountain shrub. Of the nine nests, eight were beneath sagebrush and one was beneath arrowleaf balsamroot. In eastern Idaho, Meints (1991) reported 17 (74 percent) of 23 nests were located in shrub habitats and six (26 percent) were in non-shrub habitats. Nest cover types used by CSTG (n = 51) in southeastern Idaho were equally distributed between shrub (49 percent) and herbaceous (51 percent) dominated plant communities (Apa 1998). The dominant plant species immediately above the nest included big sagebrush (32 percent), crested wheatgrass (18 percent; *Agropyron cristatum*), rabbitbrush (12 percent; *Ericameria* spp.), lupine (10 percent), and alfalfa (4 percent). In eastern Washington, Schroeder (1994) reported that 40 percent of nests (n = 10) were in the sagebrush-grass cover type, 40 percent in grass-forb communities, and 10 percent in CRP stands. In another eastern Washington study, McDonald (1998) reported 70 percent of 54 nests were in grass-forb cover, 22 percent in CRP, and 7 percent in grass-shrub cover; no nests were found in the sagebrush cover type. Columbian sharp-tailed grouse in eastern Washington primarily nested at the base of a bunchgrass or between two bunchgrasses. Bluebunch wheatgrass and Idaho fescue were the most common bunchgrasses used as nest cover in native habitats, and crested wheatgrass was used in CRP (McDonald 1998).

Giesen (1997) reported finding only one of 12 nests in a cover type other than mountain shrub; this nest was in a hay meadow under a clump of alfalfa. What Giesen (1997) identified as mountain shrub may actually have been shrubsteppe. Vegetation data collected by Giesen (1997) at CSTG use and random sites indicated the absolute density (plants per ha) of shrubs less than 1.0 m in height greatly exceeded that for shrubs greater than 1.0 m in height, with big sagebrush and snowberry having the highest absolute densities. These are characteristics more commonly associated with shrubsteppe than mountain shrub.

The distribution of 61 nests found by Boisvert (2002) was 27 (44 percent) in mine reclamation, 24 (39 percent) in shrubsteppe, six (10 percent) in CRP, three (5 percent) in grass, and one in aspen-shrub. The dominant plant species above the nest included western wheatgrass, big sagebrush, smooth brome, alfalfa, basin wildrye, and mountain snowberry (*Symphoricarpos oreophilus*). Boisvert (2002) reported that only 28 percent of females captured on leks in CRP nested in CRP, whereas 64 percent nested in shrubsteppe. In comparison, 58 percent of the females captured on leks in mine reclamation also nested in this cover type, and 34 percent nested in shrubsteppe.

Collins (2004) located 137 nests of which 99 (72 percent) were in shrubsteppe, 24 (18 percent) in mine reclamation, and 14 (10 percent) in mountain shrub. The primary overhead cover was provided by big sagebrush and rabbitbrush in shrubsteppe and by basin wildrye and alfalfa in mine reclamation. Eighty-seven of 97 (90 percent) nests (includes renests) produced by females captured on leks in shrubsteppe were in this cover type, and 10 (10 percent) were in mountain shrub. Hens captured on leks in mine reclamation primarily (60 percent) nested (n = 40) in mine reclamation, and secondarily in shrubsteppe (30 percent) and mountain shrub (10 percent). The studies by Giesen (1997), Boisvert (2002), and Collins (2004) were all conducted in northwestern Colorado. The few (n = 3) nest sites that have been described for CSTG in Wyoming were in shrubsteppe (Bredehoft 1981, Oedekoven 1985).

Nest depredation is the chief cause of reproductive failure for most prairie grouse species (Schroeder and Baydack 2001). Nest concealment by vegetation is one defense mechanism used by nesting females to reduce the risk of nest predation (Gotmark et al. 1995). Dense cover immediately surrounding the nest provides a strong barrier between the nest and senses (sight and/or smell) of predators. Because grouse nests are often subject to depredation by avian and mammalian predators, horizontal as well as vertical (overhead) cover is critical at the nest site. It is not surprising that nest success of many grouse species, sharp-tailed grouse included, has been positively correlated with greater cover at the nest site than randomly available across the landscape (Meints 1991, Riley et al. 1992, Gregg et al. 1994, McDonald 1998, McKee et al. 1998, Boisvert 2002, Collins 2004, among others).

Studies of CSTG have reported the following cover-related variables as being greater at nest sites than at random sites: grass height (Meints 1991, Schroeder 1994, Boisvert 2002, Collins 2004), grass cover (Apa 1998, McDonald 1998, Boisvert 2002, Collins 2004), visual obstruction (Meints 1991, Schroeder 1994,

McDonald 1998, Boisvert 2002, Collins 2004), litter cover (McDonald 1998), shrub cover (Meints 1991, Giesen 1997, Boisvert 2002), cover board readings (Apa 1998, Boisvert 2002), and residual vegetation (Boisvert 2002). Several of the same studies reported that bare ground, which usually increases with decreasing cover, was less at nest sites than at random sites (Meints 1991, Schroeder 1994, McDonald 1998).

Studies have not only revealed differences in structural characteristics (i.e., height and density of vegetation) of nest sites compared to random sites, but also of nest sites compared to sites within 20 m of the nest. Boisvert (2002) reported that percent residual cover and percent grass cover were higher at the nest bowl than at sites 5, 10, and 20 m from the nest. Collins (2004) also found that percent grass cover was greater, and percent bare ground was less, at the nest bowl than at sites 2.5, 5, and 10 m away. Data collected by McDonald (1998) indicated that percent bare ground increased, and percent litter cover and visual obstruction readings both decreased at increasing distances from the nest bowl. In the Curlew Valley, Idaho, CSTG that nested under sagebrush selected plants that were taller (89 versus 67 cm) and larger in circumference (9,583 versus 4,318 cm^2) than plants within a 20 m radius of the nest (Apa 1998).

Optimum nest sites in eastern Washington had visual obstruction readings of 2.79 dm, 54.2 percent grass cover, 82.8 percent litter cover, 5.6 percent bare ground, and 84 percent overhead canopy cover (McDonald 1998). Boisvert (2002) reported that CSTG nest sites in northwestern Colorado consistently had higher mean canopy cover of residual vegetation (≥ 8.5 percent) and grass (≥ 31.9 percent), and greater visual obstruction (≥ 48.8 cm) and overstory cover (≥ 62.8 percent) than at random sites (**Table 8**). Collins (2004) recommended that nesting areas in shrubsteppe should contain the following minimum characteristics: grass cover greater than 22 percent, grass height greater than 22 cm, bare ground less than 4 percent, and visual obstruction at 2.5 m greater than 48 cm (**Table 8**). For mine reclamation, Collins (2004) recommended grass cover greater than 60 percent, grass height greater than 62 cm, bare ground less than 3 percent, and visual obstruction at 2.5 m greater than 46 cm.

Table 8. Topographic and vegetation characteristics (mean values) at Columbian sharp-tailed grouse nest sites in USDA Forest Service Rocky Mountain Region (Boisvert 2002, Collins 2004). Sample sizes are in parentheses.

Characteristic	Boisvert (2002) All cover types		Collins (2004) Mine reclamation		Collins (2004) Shrubsteppe	
	1999(28)[1]	2000(33)[1]	2001(16)[1]	2002(16)[1]	2001(35)[1]	2002(24)[1]
Coverboard, %[2]	59.6	62.4	73.6	83.6	70.8	58.8
Residual cover, %	8.5	14.0	—	—	—	—
Litter cover, %	79.1	78.6	88.3	89.5	70.2	86.4
Bare ground, %	10.6	6.1	5.3	7.9	9.2	11.4
Shrub cover, %	9.7	23.9	1.8	1.8	39.9	38.5
Grass cover, %	43.6	31.9	41.9	45.5	15.5	19.3
Forb cover, %	24.3	21.9	26.1	17.4	17.4	16.5
VOR, cm[3]	29.9	33.3	57.3	53.1	70.6	64.4
Shrub height, cm	29.6	49.4	41.0	35.8	61.5	60.1
Grass height, cm	68.0	93.5	57.1	56.7	21.9	12.1
Species richness[4]	13	16	19	15	27	23
Slope, °	5	6	8.0	9.6	5.6	5.9
Elevation, m	2210	2181	2130	2149	2182	2211
Nearest edge, m	109	98				

[1]Moderate drought conditions occurred in 2000 and 2001, and extreme drought conditions occurred in 2002. Normal conditions occurred in 1999.

[2]Viewed from a height of 1.5 m and expressed as the percentage of 3x3 cm squares of 25 total squares covered by ≥ 50 percent vegetation (Jones 1968).

[3]Visual obstruction (vertical cover) measured with a 2-m cover pole read from a height of 1.5 m and distance of 10 m (Griffith and Youtie 1988). Expressed as the height at which the pole is covered by ≥ 25 percent vegetation.

[4]Total species recorded.

Microhabitat characteristics that distinguish successful from unsuccessful nest sites include the same variables that separate nests from random sites. Generally, successful nest sites provide more cover than unsuccessful nest sites do. In eastern Washington, percent bare ground was less and percent litter cover and visual obstruction were greater at successful than unsuccessful nests; grass cover and canopy cover directly above the nest bowl also were greater at successful than unsuccessful nests (McDonald 1998). Meints (1991) found that in eastern Idaho, successful nests were in sites with taller grass (26.8 ± 8.7 versus 18.4 ± 2.0 cm) and a greater mean density of shrubs greater than 20 cm in height (1.0 ± 0.3 versus 0.8 ± 0.3 shrubs per m^2) compared to unsuccessful nest sites.

Boisvert (2002) and Collins (2004) measured attributes of successful and unsuccessful nests in mine reclamation and native shrubsteppe. Boisvert (2002) reported that visual obstruction 1 m from the nest bowl was the most significant variable contributing to differences between successful and unsuccessful nests in mine reclamation (38 versus 23 cm) and shrubsteppe (38 versus 30 cm). Collins (2004) reported that grass height at the nest and 1 m from the nest were significant predictors of nest success in both mine reclamation and shrubsteppe. Mean grass height at the nest was 62.1 and 20.8 cm at successful nests in mine reclamation and shrubsteppe, respectively. The corresponding measurements at unsuccessful nests were 38.8 cm in mine reclamation and 16.8 cm in shrubsteppe. Measurements 1 m from the nest bowl were 37.5 cm for successful nests and 20.9 cm for unsuccessful nest in mine reclamation. In shrubsteppe, measurements 1 m from the nest were 21.5 cm for successful nests and 17.0 cm for unsuccessful nests. Collins (2004) also reported that visual obstruction at the nest bowl recorded from 2.5 and 10 m away was higher at successful (46.2 cm at 2.5 m and 59.1 cm at 10 m) than unsuccessful nests (31.1 cm at 2.5 m and 40.9 cm at 10 m) in mine reclamation. Visual obstruction did not differ between successful and unsuccessful nests in shrubsteppe.

Several studies have shown that macrohabitat features, such as slope, aspect, elevation, distance to nearest other cover type, and distance to nearest man-made structure, rarely differ between nest and random sites and are not as important in the selection of nest sites as microhabitat features (Apa 1998, Boisvert 2002, Collins 2004). However, there is compelling evidence to suggest that CSTG select nest sites on gentle to moderate slopes more so than steeper slopes. Average slopes at nest sites in northwestern Colorado were reported as 5° (range = 0–10°, n = 28) and 6° (range =

1–16°, n = 33) by Boisvert (2002), and as 8.0 ± 4.5° (n = 16), 5.6 ± 5.6° (n = 35), 9.6 ± 4.1° (n = 20), and 5.9 ± 2.8° (n = 36) by Collins (2004). In southeastern Idaho, 44 (86 percent) of 51 CSTG nests were on slopes less than 9 percent, and seven (14 percent) were on slopes between 10 and 19 percent (Apa 1998). The slope at 10 nest sites in eastern Washington averaged 1.7 ± 1.6 percent (Schroeder 1994).

Measurements of microhabitat characteristics at nest sites are typically made after females have completed nesting or abandoned the nest. This is done to avoid disturbing the female during egg laying and incubation. These measurements do not consider plant growth and/or senescence and may not accurately reflect the microhabitat conditions selected by the female at time of nest initiation (Hausleitner et al. 2005). Sharp-tailed grouse may select nest sites before visiting leks to breed (Gratson 1988). Thus, the period between when the female selects the nest site and when site characteristics are measured may exceed 40 days. Collins (2004) attempted to address this problem by comparing microhabitat characteristics at the approximate time of nest initiation and at time of hatch.

In 2001, Collins (2004) measured nest site characteristics at 24 successful nests immediately after the females left the nests. In 2002, Collins (2004) re-measured the same 24 nest sites at the approximate time the females selected the sites in 2001. This approach avoided the need to flush the females from the nests, but it had the disadvantage of measuring the sites the following year potentially under different growing conditions. The data indicated that several variables increased from time of nest initiation to hatch, the most notable of which were grass height at the nest and 1 m from the nest. In mine reclamation, grass height at the nest and 1 m from the nest increased from 46.4 to 67.0 cm (44 percent increase) and 20.1 to 41.2 cm (63 percent increase), respectively. In shrubsteppe, grass height at the nest increased 47 percent from 14.3 to 21.0 cm, and grass height 1 m from the nest increased 72 percent from 11.6 to 20.0 cm. This suggests the minimum grass height for suitable nesting cover may be substantially less than measured at time of hatch.

Summer and brood-rearing habitat

Columbian sharp-tailed grouse select brood habitats based on structure and composition of the vegetation (Giesen and Connelly 1993). Brood habitats must be structured so that chicks can travel easily through the vegetation, while simultaneously

providing adequate cover for protection from predators and adverse weather (Bergerud and Gratson 1988). In addition, brood habitats must support the plant species that meet the nutritional requirements of both the female and her chicks (Bergerud and Gratson 1988). Cover types that meet these criteria can vary from native grasslands and CRP with little or no shrub cover to shrubsteppe and mountain shrub communities with greater than 40 percent shrub cover. For any cover type to be suitable for brood-rearing, it must support an abundance of forbs (Hart et al. 1950, Klott and Lindzey 1990, Meints 1991, Apa 1998, Boisvert 2002, Collins 2004). Forbs are consumed by the female and by chicks as they grow. More importantly, forbs attract insects, and insects comprise over 80 percent of the chick's diet during the first two to three weeks of life (Hart et al. 1950, Jones 1966, Bernhoff 1969).

Ideally, suitable brood-rearing areas should be interspersed with suitable nesting areas to minimize the distance females must move after leaving the nest with their chicks. On native ranges, quality brood habitats can best be described as a mosaic of shrubsteppe and grassland communities that support a diversity of forbs and grasses (Giesen and Connelly 1993). Broods use grasslands for foraging in the morning and evening and retreat to shrub cover during mid-day. Within grassland communities, bunchgrasses are considered better than sod-forming grasses because they allow for easier movement through the understory. Furthermore, if left undisturbed, sod-forming grasses tend to become stunted and grow in dense mats that exclude many forbs, thus, providing poor brood habitat (Monsen 2005).

High interspersion of cover types is considered an important feature of CSTG brood habitat (Giesen and Connelly 1993, Connelly et al. 1998), presumably because of the greater "edge effect." However, there is conflicting evidence regarding the use of habitat edges by broods. In southeastern Idaho, McArdle (1977) reported that greater than 70 percent of his brood observations were 30 m or less from the nearest habitat edge. Meints (1991) reported a median distance of 50 m to the nearest other habitat for CSTG broods in eastern Idaho. In south-central Wyoming, Klott and Lindzey (1990) noted that when broods used large openings, they foraged on the edges and avoided the centers. In contrast to these studies, Boisvert (2002) found no difference in distance to habitat edge between brood and random sites for broods primarily using mine reclamation and CRP. In Boisvert's (2002) study, distance to habitat edges averaged 70 m and was highly variable (range = 1–675 m). Collins (2004) also found that use of habitat edges by broods in mine reclamation was highly variable and

on average (2000: mean = 289 ± 259 m; 2001 mean = 188 ± 200 m) greatly exceed distances reported by other investigators, including Boisvert (2002). Boisvert (2002) suggested that interspersion of cover types may be of greater importance for broods using native cover types than those using mine reclamation and CRP. Grasses are the dominant vegetation in CRP and mine reclamation, and shrubs are often rare or completely absent. In this situation, protection from predators may be enhanced if the broods become "lost in a sea of grass" rather than remain near habitat edges.

High diversity of grasses and forbs is another feature often reported as an essential component of CSTG brood habitat (Giesen and Connelly 1993, Connelly et al. 1998). While this may be true for native cover types, it may not apply to artificial cover types, such as CRP, depending on what is planted in the fields. Sharp-tailed grouse broods are known to use CRP fields where greater than 95 percent of the vegetation consists of only two to five species of grasses and forbs (Sirotnak et al. 1991, Apa 1998, McDonald 1998, Boisvert 2002, Utah Division of Wildlife Resources 2002, Rodgers and Hoffman 2005). Rodgers and Hoffman (2005) reported that fields ranging in height from 30 to 75 cm and containing a large component of alfalfa in combination with two to three species of bunchgrasses appear to be of greatest benefit to sharp-tailed grouse. In southeastern Idaho, CSTG broods extensively used fields consisting primarily of alfalfa and crested wheatgrass; forbs (mainly alfalfa) comprised nearly 40 percent of the fields (Sirotnak et al. 1991). In northern Utah, CRP lands seeded with alfalfa, tall wheatgrass (*Thinopyrum ponticum*), intermediate wheatgrass, and basin wildrye have provided valuable nesting and brood-rearing areas for CSTG (Utah Division of Wildlife Resources 2002, Rodgers and Hoffman 2005). Female CSTG transplanted to southwestern Colorado nested and raised their broods almost exclusively in CRP fields containing mostly alfalfa, tall wheatgrass, and crested wheatgrass (Colorado Division of Wildlife, unpublished data). Other forbs that frequently invade CRP fields and provide additional benefits to sharp-tailed grouse primarily as food included prickly lettuce, yellow salsify, and common dandelion.

Within Region 2, Boisvert (2002) measured macro- and microhabitat characteristics at 99 brood and 99 random sites in northwestern Colorado (**Table 9**). The distribution of brood locations by cover type was as follows: 67 percent mine reclamation, 19 percent shrubsteppe, 6 percent grasslands, 4 percent CRP, 3 percent mountain shrub, and 1 percent aspen. No differences were detected in slope, aspect, elevation,

Table 9. Topographic and vegetation characteristics (mean values) at Columbian sharp-tailed grouse brood sites in USDA Forest Service Rocky Mountain Region (Klott 1987[1], Boisvert 2002[2], and Collins 2004[3]).

Characteristic	Klott (1987)	Boisvert (2002) 1999	Boisvert (2002) 2000	Collins (2004) MR 2001	Collins (2004) MR 2002	Collins (2004) SS 2001	Collins (2004) SS 2002
Forb cover, %	28.8	32.9	21.8	24.0	26.7	15.0	11.0
Grass cover, %	32.6	36.1	25.9	17.4	28.9	17.4	15.8
Shrub cover, %	27.8	3.6	17.1	2.3	2.3	28.1	59.8
Litter cover, %	27.7	79.7	76.6	87.7	83.1	76.0	78.8
Bare ground, %	10.2	12.0	7.0	10.3	14.6	14.9	17.8
Species richness[4]	26	10	12	26	17	26	19
Shrub ht., cm	—	94.2	93.0	45.5	34.6	61.8	117.6
Grass ht., cm	—	84.7	64.6	37.7	37.9	24.9	24.7
Forb ht., cm	—	58.3	45.2	22.2	24.9	11.2	15.4
VOR, cm[5]	—	49.9	54.3	41.9	61.8	64.1	104.9
Slope, °	—	7	7	8.9	10.7	5.2	9.0
Elevation, m	—	2232	2205	2287	2168	2224	2270
Nearest edge, m	—	147	71				

[1] Combined data for 44 broods observed in 1985 and 1986 primarily in shrubsteppe and mountain shrub cover types.

[2] Data reported separately for 1999 (n = 48) and 2000 (n = 51, moderate drought year); 92 percent of broods observed in mine reclamation or shrubsteppe.

[3] Data reported separately by cover type (MR = mine reclamation, SS = shrubsteppe) for 2001 (n = 14 for MR and 22 for SS, moderate drought year) and 2002 (n = 16 for MR and 24 for SS, extreme drought year).

[4] Total species recorded.

[5] Visual obstruction (vertical cover) measured with a 2-m cover pole read from a height of 1.5 m and distance of 10 m (Griffith and Youtie 1988). Expressed as the height at which the pole is covered by ≥ 25 percent vegetation.

distance to edge, or distance to nearest road between brood and random locations. Several microhabitat variables differed between years due to differences in growing conditions; however, within years, brood sites consistently had higher mean visual obstruction readings, greater forb cover, and greater overstory cover than random sites. Boisvert (2002) further reported that unlike nest site characteristics, which were highly specific at the nest bowl compared to the immediate surroundings, brood site characteristics were more uniform across a larger area. This reflects the need of the female and her brood to move to obtain adequate resources. Alfalfa, cicer milkvetch (*Astragalus cicer*), common dandelion, asters (*Aster* spp.), maiden blue eyed mary (*Collinsia parviflora*), and American vetch (*Vicia americana*) were some of the most common forbs identified by Boisvert (2002) at brood sites. In summary, Boisvert (2002) found that females with broods used areas with greater than 20 percent forb cover that provided consistently high visual obstruction (≥ 50 cm) and canopy cover, (≥ 70 percent) mainly in the form of herbaceous (grasses and forbs) vegetation and secondarily by shrubs such as big sagebrush and snowberry.

Collins (2004) measured macro- and microhabitat characteristics at 76 brood and 79 random sites in mine reclamation and shrubsteppe in northwestern Colorado (**Table 9**). Some variables differed between years, but within years, broods in both cover types consistently used sites with greater forb cover and taller forbs than randomly available across the landscape. Grass and forb cover, and grass and forb heights were greater at mine reclamation brood sites than shrubsteppe brood sites, whereas shrub cover (big sagebrush, snowberry, serviceberry, and rabbitbrush) was greater at shrubsteppe brood sites. Forbs frequently identified at brood sites included yellow salsify, alfalfa, arrowleaf balsamroot, common dandelion, and cicer milkvetch. Collins (2004) failed to find any differences in overstory cover or visual obstruction between brood and random sites as noted by Boisvert (2002).

Of 44 broods observed in south-central Wyoming, 73 percent were in sagebrush-snowberry or mountain shrub cover types where the total shrub cover averaged 27.8 ± 13.5 percent (**Table 9**; Klott 1987, Klott and Lindzey 1990). Within these cover types, broods used sites where shrub cover and height were less

than average for the cover type. Forb cover averaged 29 percent, with sulphur buckwheat (*Eriogonum umbellatum*) usually present. Grass cover averaged 33 percent, with bulbous oniongrass (*Melica bulbosa*), bluegrasses, wheatgrasses, and needlegrasses (*Stipa* spp.) often present.

Females without chicks and males use the same cover types during summer as females with chicks. The only difference between brood and male locations in eastern Idaho was that broods used areas with taller grass (Meints 1991). In northwestern Colorado, Boisvert (2002) reported that forb cover was the only variable that differed between brood sites (1999 = 32.2 percent, 2000 = 21.8 percent) and sites used by males and females without chicks (1999 = 24.1 percent, 2000 = 11.7 percent). Giesen (1997) reported that although males and females were located most often in mountain shrub, males used hay meadows more often than expected based on availability. This selection was strongest from June to August. Females generally avoided all cover types other than native mountain shrub. Giesen (1997) made no distinction between habitat use data collected for females with and without chicks. What Giesen (1997) referred to as mountain shrub was more likely shrubsteppe.

Of 716 summer (May to September) flush sites of 15 radio-marked grouse (13 males, two females without chicks) in western Idaho, 83 percent were in big and low sagebrush (*Artemisia arbusula*) cover types (Saab and Marks 1992). Grouse avoided intermediate wheatgrass and eriogonum cover types and only used dense riparian and mountain shrub cover types as escape cover. Compared to random sites within the two sagebrush cover types, grouse selected areas with (1) greater horizontal and vertical cover, (2) greater canopy cover of forbs typically decreased by livestock grazing, (3) greater density and canopy cover of arrowleaf balsamroot, and (4) greater canopy coverage of bluebunch wheatgrass. Arrowleaf balsamroot and bluebunch wheatgrass are native perennials, and both are decreaser species (Blaisdell and Pechanec 1949). Based on these findings, Saab and Marks (1992) concluded that CSTG were selecting areas least modified by livestock grazing. They found no evidence that CSTG sought free water during summer. Mean distance to water was 297 ± 183 m and did not differ from random sites. Parker (1970) and Klott (1987) similarly concluded that CSTG did not seek free water.

Fall habitat

Columbian sharp-tailed grouse continue to use the same habitats during fall that they occupied throughout the summer (Giesen 1997, Boisvert 2002). They remain on summer use areas until the snow accumulates and causes them to move to wintering areas. Males start spending more time on and near the leks as fall approaches. Because of their attraction to the leks, males tend to remain on the summer range longer than females do. During the day, CSTG may move to patches of serviceberry and chokecherry to feed on ripening fruits. Although wheat fields occur throughout the range of CSTG, use of wheat varies locally and regionally. Giesen (1997) documented some use of wheat fields in northwestern Colorado during fall immediately after grain harvest. Hoffman (1980) also reported observing CSTG using wheat fields in northwestern Colorado during fall. Dargan et al. (1942) and Rogers (1969) both considered wheat fields an important component of CSTG habitats in northwestern Colorado. Contrary to these reports, Boisvert (2002) and Collins (2004) documented no use of agricultural lands by CSTG during any time of year on their study areas in northwestern Colorado.

Winter habitat

The onset of winter generally causes a marked shift in habitat use patterns of CSTG (Giesen and Connelly 1993, Connelly et al. 1998). Cover types most frequently used by CSTG during winter include mountain shrub, riparian, and aspen (Hart et al. 1950, Parker 1970, Hofmann and Dobler 1988b, Marks and Marks 1988, Meints 1991, Ulliman 1995b, McDonald 1998, Boisvert 2002). The shrub component within these cover types often averages over 1 m in height and includes at least one or two of the following species: serviceberry, chokecherry, willow, hawthorn, and birch.

Columbian sharp-tailed grouse also have been reported using CRP fields, open juniper woodlands, Russian olive (*Elaeagnus angustifolia*) stands, and wheat fields during winter (Marks and Marks 1988, Meints 1991, Sirotnak et al. 1991, Ulliman 1995b, McDonald 1998). Use of predominantly herbaceous cover types, such as CRP and wheat, and low (<1 m) shrub types during winter is a function of snow depths. As snow accumulates, CSTG abandon these cover

types in favor of mountain shrub and riparian areas that support tall shrubs that protrude above the surface of the snow. Giesen and Connelly (1993) considered the presence of mountain shrub or riparian shrub communities essential for the long-term persistence of CSTG populations.

Marks and Marks (1988) documented 108 winter locations of CSTG in western Idaho, of which 35 were in mountain shrub, 28 in big sagebrush, 25 in riparian areas, 18 at seeps, and two in unclassified cover types. They reported that 88 percent of their winter observations were within or near ($\leq$ 50 m) mountain shrub or riparian cover types. The principal species in the mountain shrub type were serviceberry and chokecherry while hawthorn was the dominant species in riparian areas used by CSTG. Use of cover types differed among winters. Forty-two percent of 52 winter locations during 1983–84 occurred in the riparian hawthorn cover type compared to only 5 percent of 56 locations in this cover type over the following two winters. Variations in cover types used within and among winters were attributed to changes in food availability and snow conditions.

On one study area in eastern Idaho, Meints (1991) reported that large ($\geq$ 200 grouse) winter concentrations of CSTG fed in grain fields during the morning and returned to aspen and mountain shrub patches during the day. On another nearby study area, winter use was limited to chokecherry patches and stands of Utah juniper (*Juniperus osteosperma*). McArdle (1977) reported that winter use by CSTG in southeastern Idaho was confined to areas with greater than 40 percent shrub cover. Ulliman (1995b) found major differences in habitat use patterns of radio-marked grouse from one winter to the next in southeastern Idaho. During the mild winter of 1992, radio-marked grouse used CRP fields and remnant sagebrush patches within the CRP fields. During the more severe winter of 1993, grouse primarily used riparian and mountain shrub cover types although some birds remained in the sagebrush type near patches of Russian olive (Ulliman 1995b). Compared to random sites, grouse use sites had more alfalfa and yellow salsify in 1992, and more serviceberry in 1993.

In eastern Washington, Hofmann and Dobler (1988b) observed 117 CSTG during winter. These grouse used several cover types but were primarily in big sagebrush (34 percent), riparian areas (26 percent), and wheat fields (17 percent). Riparian stringers with water birch were identified as critical winter habitat. As snow depths increased, so did use of riparian areas. During winter in eastern Washington, McDonald (1998) also observed CSTG using a diversity of cover types, including CRP, grass-forb, grass-shrub, big sagebrush, riparian/mountain shrub, and wheat. Use depended upon snow cover, with use of shrub-dominated cover types (i.e., sagebrush and riparian/mountain shrub) increasing as snow depths increased. Two cover types, riparian/mountain shrub and wheat, were used solely during winter. McDonald (1998) reported that use of the riparian/mountain shrub cover type was likely under-represented and sagebrush over-represented in his study. Grouse were often found later in the day when they were roosting in the sagebrush cover type, but inspection of their droppings indicated they had been feeding almost exclusively on water birch along nearby riparian stringers.

Clearly, CSTG can exploit a variety of habitats during winter, but most use is confined to one or two cover types due to snow depths. This is particularly true in Region 2 where CSTG occur at higher elevations than elsewhere throughout the subspecies' range. Within Region 2, Boisvert (2002) documented no use of CRP, mine reclamation, native grasslands, agricultural lands, or riparian corridors during winter and only limited use of shrubsteppe. The primary cover type used by CSTG during winter was mountain shrub (**Figure 6**; 58 percent of locations) followed by aspen (22 percent). The aspen stands used by sharp-tailed grouse during winter supported a relatively dense understory of mountain shrubs (Boisvert 2002). Grouse were seldom observed in aspen stands with predominantly herbaceous understories unless they were flushed into the trees from nearby mountain shrub patches. Use of shrubsteppe (20 percent of locations) was confined to south slopes, and stands of mountain shrub generally occurred nearby ($\leq$ 100 m). Serviceberry was the single most common shrub found at CSTG winter locations (**Figure 6**). Topographically, areas used by CSTG during winter were at higher elevations (2,202 to 2,593 m) than breeding-summering areas (2,076 to 2,280 m) and tended to be on north slopes with deep, soft snow suitable for roosting (Boisvert et al. 2005).

Similar to Boisvert (2002), Collins (2004) documented no use of CRP, mine reclamation, agricultural lands, or riparian corridors, some use of shrubsteppe, and extensive use of mountain shrub by CSTG during winter in northwestern Colorado. Unlike Boisvert (2002), Collins (2004) observed occasional use of open Rocky Mountain juniper (*Juniperus scopulorum*) woodlands interspersed with shrubsteppe and patches of mountain shrub. From December through late March in Wyoming, Oedekoven (1985) observed CSTG primarily in serviceberry-aspen, cottonwood-willow riparian, hawthorn riparian, serviceberry-chokecherry,

Figure 6. Columbian sharp-tailed grouse winter habitat in USDA Forest Service Rocky Mountain Region primarily consists of mountain shrub communities dominated or co-dominated by serviceberry. Photograph by Richard W. Hoffman.

and sagebrush-mixed shrub. Oedekoven (1985) stressed the importance of woody cover in collecting snow and creating conditions suitable for snow roosting, which he believed was critical to the winter survival of CSTG in south-central Wyoming.

Landscape configuration and size

Several studies have emphasized the importance of nesting and brood-rearing habitats while others have shown the necessity of winter foraging and roosting habitats. Although individually all of these habitats are critical, it is their quality, quantity, inter-relatedness, and configuration across the landscape that are crucial for supporting healthy populations of CSTG (Giesen and Connelly 1993, Tirhi 1995, Hoffman 2001). The Northwest Colorado Columbian Sharp-tailed Grouse Conservation Plan recommends maintaining 20 percent of the landscape in deciduous shrub-dominated communities, 20 percent in sagebrush-dominated communities, 15 percent in grasslands, 5 percent in aspen, and 5 to 10 percent in CRP and mine reclamation (Hoffman 2001). These types must be well distributed across the landscape. Ideally, for each lek site, suitable escape cover should occur within 400 m, suitable nesting and brood-rearing cover within 2.0 and

preferably 1.0 km, and suitable winter habitat within 4 km and no more than 6.5 km. Within a 2.0 km radius of the lek, a minimum of 50 percent of the area should be suitable for nesting and brood-rearing. Within 6.5 km, at least 10 percent of the landscape should consist of suitable winter habitat.

The minimum amount of area required to support a self-sustaining population of CSTG is unknown and highly dependent on the quality and juxtaposition of suitable breeding, nesting, brood-rearing, and wintering areas. Bart (2000) reported that no known populations of CSTG persist on areas less than 50 km^2 in size. Connelly et al. (1998) recommended 30 km^2 as the minimum area necessary for a successful reintroduction, provided at least 33 percent of the landscape consists of undisturbed grass-shrub cover. A population viability analysis conducted on prairie sharp-tailed grouse in Wisconsin indicated a spring population of 280 birds on 4,000 ha would be the minimum necessary to insure the population persisted for at least 50 years (Temple 1992). Assuming a 1:1 sex ratio and an average lek size of 16 males, this equates to nine total leks or one lek every 4.4 km^2. No data sets that span sufficient years are available to conduct a meaningful population viability analysis for any population of CSTG.

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Population connectivity

At one time populations of CSTG were scattered throughout western Colorado (Rogers 1969, Giesen and Braun 1993). Corridors of suitable habitats probably allowed for some movement between populations (Rogers 1969). Presently, one contiguous population of CSTG exists in Region 2 in northwestern Colorado and south-central Wyoming (Hoffman 2001). There are no obvious barriers impeding movements within this metapopulation. An effort is underway to establish another population in southwestern Colorado. If the transplant is successful, the newly established population will be separated from the larger metapopulation by over 300 km. Other potentially suitable transplant sites (i.e., north and south ends of the Uncompahgre Plateau, Cerro Summit, Pinõn Mesa) occur in between, but large tracts of mostly unsuitable habitat make it unrealistic to link the transplanted population in southwestern Colorado with the established population in northwestern Colorado. For the same reason, it is equally unrealistic to attempt to link populations in Region 2 with the nearest other populations in Utah and Idaho. However, it may be possible to link occupied habitats in northwestern Colorado with potentially suitable but unoccupied habitats nearby (<40 km) in Middle Park and North Park. It also may be possible to expand the population in northwestern Colorado southward into Rio Blanco and Garfield counties and further to the west in Moffat County. Conceivably, it also may be possible to establish and link populations in southwestern Colorado. For example, if populations are established on the north end on the Uncompahgre Plateau and on Pinõn Mesa, then these two areas are only separated by Unaweep Canyon, and interchange between the two populations would be possible. Expansion of the population in south-central Wyoming is unlikely, but opportunities may exist to establish new populations in southwestern and west-central Wyoming and link these populations with established populations in northern Utah and eastern and southeastern Idaho.

Although the population in northwestern Colorado has increased, there is no evidence to suggest that it has expanded its range (Hoffman 2001). This is in contrast to populations in Utah where wildlife officials estimate the distribution has increased approximately 400 percent in response to the implementation of the Conservation Reserve Program (Utah Division of Wildlife Resources 2002). Columbian sharp-tailed grouse in northwestern Colorado are known to move over 40 km between breeding and wintering areas (Collins 2004, Boisvert et al. 2005), but these long movements have not resulted in expansion of the population. For instance, CSTG breeding in Moffat County frequently move south to suitable wintering areas in Rio Blanco County (Collins 2004). However, suitable breeding habitats in Rio Blanco County remain mostly unoccupied; to date, only one active lek has been located in Rio Blanco County. Trapping and moving grouse from Routt and eastern Moffat counties to unoccupied habitats in Rio Blanco, Garfield, and western Moffat counties may not be a viable option because birds released may return to where they were captured. It may be necessary to obtain birds from populations outside of Colorado to successfully expand the range of CSTG in northwestern Colorado.

Nutritional ecology

Feeding behavior

Columbian sharp-tailed grouse may feed anytime throughout the day, but intense feeding bouts occur at dawn and dusk. Under severe winter weather, CSTG may only feed once during the day. Food is stored in a well-developed crop for later digestion. Sharp-tailed grouse, like most other grouse species, have a large muscular gizzard for grinding food. The gizzard is especially important in grinding coarse foods that comprise the bulk of the winter diet. From April through October, most feeding is from the ground, but birds may fly into and perch in trees and shrubs to feed on buds, leaves, and fruits. During the winter, especially in Region 2, most feeding occurs in shrubs and at times in trees. When not feeding, the grouse are on the ground where they roost on the surface or beneath the snow.

Food habits

The food habits of CSTG are poorly documented (Giesen and Connelly 1993). Much of what is known is based on analyses of droppings (Marshall and Jensen 1937, Hart et al. 1950, Jones 1966), which may under-estimate the importance of highly digestible foods. Ulliman (1995b) suggested that at the macro-level, the food habits of CSTG appear to be similar to those of plains and prairie sharp-tailed grouse for which substantially more information has been published (Aldous 1943, Grange 1948, Edminster 1954, Kobriger 1965, Hillman and Jackson 1973, Evans and Dietz 1974, Sisson 1976, Thomas 1984, Mitchell and Riegert 1994). Sharp-tailed grouse are primarily vegetarians throughout the year with the exception of young chicks (Connelly et al. 1998). Composition of the diet varies regionally and locally from one year to the next depending on food availability. While CSTG consume a wide array of plants and insects, the bulk of the diet

often consists of only three or four different items at any one time.

Throughout much of its range, and particularly in Region 2, food habits of CSTG differ markedly between winter and other seasons of the year. During winter, the diet primarily consists of buds, persistent fruits, and cultivated grains (where available) and gradually shifts to forbs in spring as the snow melts. By mid- to late spring, the diet consists of forbs and grasses. Forbs continue to be the main item in the diet throughout the summer along with insects, fruits, and seeds as they become available. Insects are critically important in the diet of chicks during the first three to four weeks of life. Consumption of insects by young plains sharp-tailed grouse in Nebraska accounted for 92 percent of their diet during the first three weeks of age, 63 percent at seven weeks, and 9 percent at 12 weeks (Kobriger 1965). Forbs, insects, seeds, fruits, and cultivated grains are all foods that may be consumed during fall. The actual proportion of the diet comprised of these items will vary locally and regionally depending on availability. Usually by late fall or early winter, sufficient snow has accumulated to force the birds to shift to a diet of buds and persistent fruits. During mild winters, sharp-tailed grouse may supplement their winter diet of buds with grasses and forbs.

Marshall and Jensen (1937) made one of the earliest attempts to identify the foods of CSTG in the Cache Valley in northern Utah. Their study was conducted from October through May and was based on analyses of droppings, field observations of actual feeding, and interpretation of tracks and other sign on the snow. They observed that CSTG do not scratch or dig for food and only feed on foods on or above the surface of the ground or snow. Their findings clearly reflected a marked correlation between the foods eaten and changing snow depths. Food items consumed during fall (October and November) included wheat, sunflower, and grass seed heads. From December through February, CSTG ate foods that protruded above the snow, such as buds of chokecherry and maple, and seed heads of sagebrush and sunflowers. If snow conditions permitted, they also consumed wheat and green grass blades. As the snow melted in spring (March through May), wheat, green grass blades, alfalfa, and insects became increasingly important foods. The food habits of CSTG in this region were a reflection of habitat conditions. Much of the native habitat had been converted to agriculture. The remaining patches of native vegetation were degraded due to overgrazing and provided little in the way of food. The primary food items during spring and fall were obtained from agricultural lands.

Hart et al. (1950) summarized and expanded upon the work conducted by several investigators on CSTG in the Cache Valley, including the study by Marshall and Jensen (1937). They reported the monthly rank of principal foods consumed by CSTG as ascertained by combining the food habits data collected over 15 years of study from field observations and examination of dropping, crop, and stomach contents (**Table 10**). In contrast to Marshall and Jensen (1937), Hart et al. (1950) reported more serviceberry and knotweed and no maple in the winter diet, and the presence of rose (*Rosa* spp.) hips in the fall diet. Hart et al. (1950) also identified summer (June through September) foods of CSTG, which Marshall and Jensen (1937) did not report. Neither Marshall and Jensen (1937) nor Hart et al. (1950) made any distinction between foods eaten by males and females. Hart et al. (1950) does mention that the diet of juvenile grouse during the first two to three weeks of life consisted of 80 to 100 percent insect material, with plant material appearing in the diet at four to five days of age.

Marshall and Jensen (1937) and Hart et al. (1950) may have misinterpreted some field observations of grouse feeding. Both reported use of mule-ears (*Wyethia* spp.) and sagebrush leaves and seeds. While use of sagebrush seeds is likely, consumption of sagebrush leaves and mule-ears is questionable. It may have appeared that grouse were eating the plant material, but it is more likely they were gleaning insects from the plants.

Green plant material represented 96 percent of the total volume of foods eaten by CSTG in eastern Washington during spring and summer, with Sandberg's bluegrass, early buttercup (*Ranunculus glaberrimus*), and common dandelion the most frequently identified food items (Jones 1966). Fall foods consisted primarily (68 percent) of plant material and secondarily of insects (32 percent). The most frequently identified fall foods were common dandelion, grasshoppers, and grass leaves.

Parker (1970) examined 149 crops from CSTG collected during summer (*n* = 49) and fall (*n* = 100) in southeastern Idaho (**Table 11**). Over 50 different items were identified, but three or four items consistently comprised more than 80 percent of the total dry weight of the crop contents. Juveniles consumed more insects than adults did during summer. Consumption

Table 10. Relative monthly rank of principal foods of Columbian sharp-tailed grouse in northern Utah based on observations and analyses of dropping, stomach, and crop contents (from Hart et al. 1950).

Month	Foods consumed (in order of probable importance)
January	Chokecherry buds Serviceberry buds Knotweed seeds Grass seeds and leaves Wheat seeds
February	Chokecherry buds Serviceberry buds Rose hips Sunflower seeds
March	Wheat seeds Grass seeds Sunflower seeds Sagebrush seed heads
April	Wheat Alfalfa Grass seeds and leaves Insects
May	Alfalfa Grass leaves Wheat seeds Wyethia
June, July, and August	Grass seeds and leaves Insects Sagebrush leaves and seed heads Alfalfa leaves Chokecherry fruits
September	Grass seeds and leaves Chokecherry fruits Snowberry seeds Insects
October	Grass seeds and leaves Wheat Sunflower Rose hips
November and December	Wheat Grass seeds and leaves Sunflower Knotweed

of insects by juveniles declined with increasing age. Once juvenile grouse switched to plant material, they consumed the same foods as adults. Fall diets differed between years, with insects assuming a more important role as food during dry years because favored annual forbs, such as yellow salsify, knotweed, and prickly lettuce, were less abundant.

Marks and Marks (1987) examined 132 feeding sites of CSTG over three winters in western Idaho. During winter 1983-84, grouse fed extensively on hawthorn fruits in riparian areas. No evidence was found to suggest that the grouse ate hawthorn buds. When hawthorn fruits were unavailable, grouse used mountain shrub stands, where they primarily fed on

Table 11. Primary foods of Columbian sharp-tailed grouse in southeastern Idaho during summer and fall, expressed as percent of total dry weight of crop contents (from Parker 1970). Sample sizes are in parentheses.

Food item	Summer		Fall[1]	
	Juvenile (n = 13)	Adult (n = 33)	1968 (n = 57)	1969 (n = 43)
Mahonia repens	11	16	36	37
Tragopogon dubius	21	47	28	1
Taraxacum officinale	6	1	2	1
Polygonum douglasii	5	13	14	7
Eriogonum spp.			1	3
Epilobium spp.			2	1
Rosa spp.			3	1
Triticum aestivum		6		
Lactuca serriola		2	12	
Prunus virginiana		1	1	3
Amelanchier alnifolia				3
Oryzopsis hymenoides		2		
Insects	51[2]	8	1	43[3]

[1] Data for juvenile and adult grouse were combined.

[2] Primarily grasshoppers, ants, and beetles.

[3] Primarily grasshoppers.

buds of serviceberry and chokecherry. Bitter cherry (*Prunus emarginata*) was the most numerous shrub in the stands but CSTG seldom fed on it. Grouse were occasionally observed eating buds of willow, fruits and foliage of juniper, thistle seeds, and green grass near seeps.

Schneider (1994) investigated the winter food habits of CSTG in southeastern Idaho. Diet composition was reported as percent use on a dry weight basis (dry weight of each food item divided by total dry weight of all food items present in the crops times 100) and as frequency of occurrence (**Table 12**). Columbian sharp-tailed grouse consumed twenty-five different forage species (seven shrubs, 15 forbs, three insects) during winter, but percent use exceeded 2 percent for only three shrubs, three forbs, and one insect. Percent use of buds and fruits from shrubs over two winters was greater than 80 percent (**Table 12**). Grouse (*n* = 46) collected from riparian and mountain shrub habitats selected (percent use = 84–100%) buds, fruits, and twigs from chokecherry and serviceberry (**Table 12**). Yellow salsify, alfalfa, and draba (*Draba* spp.) were the dominant foods (frequency of occurrence >98 percent) in crops of birds (*n* = 6) collected from CRP fields during winter (**Table 12**). Russian olive berries and midge galls (*Rhypolomyia* spp.) obtained from sagebrush plants comprised greater than 99 percent of the foods eaten by five grouse collected from Russian olive-sagebrush habitats (**Table 12**).

Schneider (1994) compared crop contents with microscopic fecal analysis to ascertain whether the latter technique was a viable, non-lethal alternative for sampling grouse diets. The comparisons produced conflicting results, leading Schneider (1994) to conclude that microscopic fecal analysis was not a reliable technique for describing CSTG winter food habits. Results of the fecal analysis indicated willow and aspen comprised over 61 percent of the diet, and chokecherry and serviceberry about 23 percent of the diet; the same combination of foods comprised less than 5 percent and greater than 82 percent of the crop contents, respectively.

Detailed food habits studies have not been conducted on CSTG in Region 2. However, many of the plants and insects identified as food in other areas also occur in Region 2 and are likely consumed by CSTG. Dargan et al. (1942) documented the food habits of CSTG in northwestern Colorado by trailing (following tracks) birds in snow and recording the plants upon which they fed. Data collected on 22 individual grouse from December through February indicated that they fed almost exclusively (>95 percent of diet) on chokecherry and serviceberry buds. Rogers (1969) reported that two

Table 12. Percent use[1] (frequency of occurrence) of food items identified from Columbian sharp-tailed grouse crops collected during winter 1992 and 1993 in southeastern Idaho (from Schneider 1994).

Food item	Pocatello Valley Winter 1992 (n = 18)	Pocatello Valley Winter 1993 (n = 34)	Curlew Valley Winter 1993 (n = 5)
Amelanchier alnifolia buds	27.2 (5)	51.3 (31)	0
Prunus virginiana buds	45.0 (8)	33.7 (32)	0
A. alnifolia fruits	1.8 (1)	6.2 (20)	0
P. virginiana fruits	0	T[3] (2)	0
Twigs[2]	0	1.3 (20)	0
Populus tremuloides buds	0	1.9 (2)	0
Salix spp. buds	0	1.4 (3)	0
Chysothamnus viscidiflorus	2.9 (5)	0.2 (4)	0
Elaeagnus angustifolia buds	0	0	0.3 (1)
E. angustifolia fruits	0	0	84.7 (4)
Rosa woodsii hips	0	0	0.2 (1)
Triticum aestivum	1.0 (1)	0.4 (1)	0
Grass	0.9 (5)	0.6 (9)	0
Medicago sativa	2.3 (8)	2.2 (1)	0
Antennaria spp.	T (1)	0.2 (2)	0
Astragalus spp.	0	0.1 (2)	0
Ranunculus testiculatus	0.2 (2)	0	0
Lithospermum ruderale	0	0.1 (1)	0
Draba spp.	1.4 (9)	T (4)	0
Tragopogon dubius	0.5 (2)	0	0
Thelypdium spp.	0.8 (2)	0	0
Arabis spp.	T (1)	0	0
Lactuca serriola	0.1 (2)	T (1)	0
Caryophyllaceae (pink)	2.1 (5)	T (3)	0
Liliaceae (lilly)	0	T (1)	0
Polemoniaceae (phlox)	0.1 (1)	0.1 (3)	0
Unknown forbs	T (1)	0.2 (8)	0
Acrididea (grasshopper)	0.2 (1)	T (1)	0
Rhypolomyia (midge) galls	0.1 (1)	0.1 (6)	14.4 (3)
Geometridae (moth) eggs	0	T (2)	0

[1]Calculated as dry weight of each food item divided by total dry weight of all food items present in the crops times 100.

[2]Includes twigs of *Amelanchier alnifolia* and *Prunus virginiana*.

[3]T = trace = < 0.05 percent.

crops collected on Pinõn Mesa near Grand Junction, Colorado were filled with woolly-bear (*Isia isabella*) larvae. Common items found in crops of radio-marked grouse that were depredated and subsequently recovered during studies (Boisvert 2002, Collins 2004) in northwestern Colorado included maiden blue eyed mary (spring), alfalfa (spring, summer, and fall), common dandelion (spring, summer, and fall), yellow salsify (spring and summer), prickly lettuce (spring and summer), pale agoseris (spring and summer), quaking aspen catkins (spring), Rocky Mountain juniper berries (winter), grasshoppers (summer and fall), ants (summer), serviceberry fruits (summer and fall), and serviceberry buds (winter).

Sharp-tailed grouse, as well as other gallinaceous species, ingest small stones (grit) that accumulate in the gizzard (McCann 1939, Hoskin et al. 1970, May and

Braun 1973, Norris et al. 1975, Schneider 1994). Grit facilitates digestion by assisting in mechanical abrasion of coarse or hard foods (Nestler 1946, May and Braun 1973). Schneider (1994) analyzed gizzards from 49 CSTG collected over two winters. Grit was present in 86 percent of the gizzards examined. Of the seven gizzards that contained no stones, four contained only chokecherry seeds, one contained only serviceberry seeds, and two contained no stones or seeds. During the mild winter of 1992 when grit was readily available, stone mass and number of stones per gizzard averaged 0.64 g and 21.8, respectively. In 1993, persistent snow cover reduced the availability of grit, and stone mass and number of stones per gizzard averaged only 0.30 g and 9.1, respectively. Mean stone size did not differ between winters (1992 = 2.13 mm, 1993 = 2.26 mm). Comparisons between males and females indicated no differences in mean number, mass, or size of stones. Schneider (1994) found that during winters of reduced stone availability, CSTG retained chokecherry seeds in their gizzards. These seeds were worn, suggesting that they functioned in the same manner as stones in grinding of winter foods.

Food selection

Selection of plants and plant parts by grouse during winter when their diets are highly restricted has generally been associated with higher protein levels (Hoffmann 1961, Pulliainen 1970, Gurchinoff and Robinson 1972, Hohf et al. 1987) or lower levels of secondary plant constituents (Bryant and Kuropat 1980, Remington and Braun 1985, Jakubas et al. 1989). Schneider (1994) found no evidence that CSTG selected winter foods based on crude protein content or total phenolics. He cautioned that measuring total phenolics might not reflect food selection patterns. Plants often contain a large number of secondary plant compounds (Robbins 1993), any of which could act as a possible deterrent to feeding. Jakubas et al. (1989) reported no differences in total phenolics between preferred and non-preferred forages (i.e., aspen buds) of ruffed grouse. Upon further investigation, Jakubas et al. (1989) found that ruffed grouse feeding preferences were related to levels of coniferyl benzoate, a specific phenolic found in aspen bud scales. Schneider (1994) recommended that the role of secondary plant compounds on foraging behavior of CSTG needs further study before specific conclusions can be reached. Winter forage selection by CSTG may represent a strategy of maximizing intake of metabolizable energy while meeting nitrogen requirements similar to what Remington and Hoffman (1996) reported for dusky grouse. Dusky grouse preferred foods from which they extracted the most energy, but these foods were not necessarily superior by conventional nutritional analyses (Remington and Hoffman 1996).

Studies indicate that CSTG remain in shrubsteppe or CRP cover types when snow conditions permit (Sirotnak et al. 1991, Schneider 1994, Ulliman 1995b, McDonald 1998). Within these cover types, they primarily feed upon forbs, berries, and insects, whereas grouse using mountain shrub mainly consume buds from deciduous shrubs. Schneider (1994) reported that grouse using CRP fields in southeastern Idaho consumed foods with more protein and minerals, and less fiber and total phenolics than grouse in mountain shrub habitats. This may explain why the grouse remained in CRP when snow conditions allowed. This is seldom an option for CSTG in Region 2 even during mild winters. Columbian sharp-tailed grouse in Region 2 are almost exclusively confined to feeding in mountain shrub habitats during winter. As previously discussed, CSTG appear to select specific areas within the mountain shrub cover type in winter. It is feasible that CSTG select these areas in part based on the nutritional characteristics of the serviceberry plants (primary winter food of CSTG in Region 2) growing there. This aspect of CSTG habitat selection in Region 2 needs further investigation.

Energetics

The specific nutritional requirements of CSTG are not known (Connelly et al. 1998). There is no empirical information on gross daily food consumption by CSTG in the wild or in captivity. McEwen et al. (1969) estimated the average daily intake of plains sharp-tailed grouse raised in captivity as 30 g air-dry weight per mature grouse. This estimate has little value in extrapolating to wild birds because captive birds were fed a combination of commercial game bird chow, mixed grains, and alfalfa hay.

Evans and Dietz (1974) conducted feeding trials of plains sharp-tailed grouse captured in the wild and maintained in captivity during winter. The trials involved feeding three to four grouse a single-component diet for four days and measuring total intake and collecting all excreta. Male grouse were fed one of the following seven food items: corn kernels, buds from plains cottonwood (*Populus deltoides*), and fruits from silver buffaloberry (*Shepherdia argentea*), hawthorn, Russian olive, western snowberry (*Symphoricarpos occidentalis*), and Woods' rose (*Rosa woodsii*). Mean daily intake (dry matter) ranged from 21.5 g per grouse per day for air-dried cottonwood buds to 100.3 g per grouse per day for frozen western snowberry fruits.

Female grouse were fed silver buffaloberry, Russian olive, and hawthorn; the corresponding intake was 38.5, 47.5, and 55.7 g per grouse per day. Females consumed an average of 31.5 percent less dry matter when fed the same food as males. Grouse lost nitrogen on a diet of cottonwood buds and Woods' rose, maintained a zero nitrogen balance on corn, Russian olive, and hawthorn, and gained nitrogen on western snowberry and silver buffaloberry fruits. Average nitrogen-corrected metabolizable energy values (kcal per g of dry matter intake) ranged from 3.9 for corn to 1.4 for rose. Despite the lower intake by females, metabolizable energy values did not differ by gender. Captive grouse varied their metabolizable energy intake from 58 to 444 kcal per day depending on the food they were being fed. Under winter conditions, Evans (1971) estimated that sharp-tailed grouse require an intake of at least 100 kcal per day to maintain a constant body weight.

Columbian sharp-tailed grouse in Region 2 are believed to persist on a nearly monophagous diet of serviceberry and/or chokecherry buds during most winters. Giesen (1992) and Collins (2004) reported that mean body mass of adult male CSTG harvested or captured during fall was less than mean body mass of adult males captured on leks during spring. This implies that adult males gain weight over winter while presumably persisting on a diet of serviceberry buds. Greater sage-grouse (Beck and Braun 1978), white-tailed ptarmigan (May 1975), and sooty grouse (*Dendragapus fuliginosus*; Zwickel and Bendell 2004) are other examples of grouse that gain weight over winter while subsisting on a diet of one or two plant species.

Compared to items eaten at other times of the year, winter foods consumed by grouse are often less nutritious but more abundant and readily available. The basic feeding strategy of grouse with restricted winter diets, such as CSTG, is to pass large quantities of food through their digestive system. This strategy is possible because grouse have large, well-developed crops that allow them to store food for later processing. Captive sharp-tailed grouse fed a low protein diet of hawthorn fruits compensated for the lack of protein and maintained nitrogen balance by consuming large quantities of berries (Evans and Dietz 1974).

Schneider (1994) measured the nutrient levels (dry mass basis) for dominant foods selected by CSTG during winter in southeastern Idaho. This analysis included chokecherry and serviceberry buds, two of the most common foods consumed by CSTG in Region 2 during winter. Nutrient levels for chokecherry averaged 14.7 percent crude protein, 51.2 percent fiber, 4.5 percent lipids, 4.5 percent minerals, 2.3 percent total phenolics, and 4.8 kcal per g gross energy. For serviceberry, the mean nutrient levels were 8.4 percent crude protein, 50.2 percent fiber, 5.7 percent lipids, 5.1 percent minerals, 2.7 percent total phenolics, and 4.7 kcal per g gross energy. In comparison, gross energy and crude protein of silver buffaloberry, one of the common foods of plains sharp-tailed grouse, average 4.9 kcal per g and 8.4 percent, respectively (Evans and Dietz 1974). Captive grouse maintained a positive nitrogen balance and gained weight on a diet of silver buffaloberry (Evans and Dietz 1974).

Demography

Genetic considerations

Sharp-tailed grouse, greater prairie-chickens, and lesser prairie-chickens (genus *Tympanuchus*) are genetically distinct from other grouse species (Ellsworth et al. 1995, 1996). However, within the genus *Tympanuchus*, no clear genetic distinctions occur among species for either mtDNA or allozymes despite marked behavioral and morphological differences (Ellsworth et al. 1994). Two hypotheses may account for the similarity among the three taxa. The first is that differentiation occurred in geographic isolation during Pleistocene glacial advances, but genetic evidence of such an event has been lost upon secondary contact due to hybridization. Ellsworth et al. (1994) acknowledged that sporadic hybridization occurs among prairie grouse, but they contended it is more common currently (post-settlement) than historically (pre-settlement) and, therefore, is not a significant factor affecting genetic similarity within *Tympanuchus*. The second hypothesis proposed by Ellsworth et al. (1994) is that subdivision among prairie grouse occurred during the Wisconsin glacial period (Hubbard 1973), which was sufficiently recent so that all populations of *Tympanuchus* still retain (share) ancestral genetic polymorphisms that arose prior to divergence. In other words, mtDNA lineages may not have had sufficient time to sort phylogenetically such that each taxon constitutes a distinct lineage. Ellsworth et al. (1994) proposed that morphological and behavioral differentiation among sharp-tailed grouse, greater prairie-chickens, and lesser prairie-chickens has been driven by sexual selection and appears to have evolved rapidly relative to mtDNA and allozymes.

Spaulding et al. (2006) provided evidence that populations of CSTG in British Columbia, Washington, Idaho, and Utah are genetically distinct from other subspecies of sharp-tailed grouse and should be

managed as a distinct entity. Analyses of nuclear data obtained from CSTG in northwestern Colorado (Region 2) indicated a closer alliance with plains sharp-tailed grouse than CSTG collected in British Columbia, Washington, Idaho, and Utah (Spaulding et al. 2006). While Spaulding et al. (2006) did not go so far as to say that the sharp-tailed grouse in northwestern Colorado are not of the Columbian subspecies, they did report that those grouse are genetically different from other populations of CSTG sampled. They recommended that CSTG in northwestern Colorado not be used as a source of transplant stock outside of Colorado until the uncertain status of this population is further investigated. Spaulding et al. (2006) did not include any samples of CSTG from Wyoming in their analyses. Presumably, the Colorado and Wyoming populations have similar genetic characteristics, since they are contiguous. This should be confirmed by collecting and analyzing samples from Wyoming along with additional samples from Colorado. In conjunction with genetic surveys, studies of morphology, behavior, and habitat use should be undertaken to further characterize sharp-tailed grouse in this portion of the range.

Fundamental to population genetics is the knowledge that small or isolated populations lose genetic variation over time, thereby increasing the probability of extinction and decreasing the probability of future adaptive change (Lande and Barrowclough 1987). The genetic structure of a population is affected, in part, by gene flow. As gene flow decreases, genetic variation is lost due to random genetic drift (Ewens et al. 1987, Slatkin 1987). Genetic variation is believed to be important for a population's long-term persistence because it reduces the deleterious effects of inbreeding and random loss of alleles through genetic drift. For CSTG, broad-scale loss and fragmentation of suitable habitats throughout its range have isolated remaining populations to the extent that there currently is little or no possibility of natural gene flow among populations. If loss and degradation of suitable habitats continues, genetic consequences may be serious. Recent genetic studies suggest that some consequences are already happening. For example, Warheit and Schroeder (2001) analyzed blood samples from CSTG collected in north-central Washington and southeastern Idaho and found that the populations were significantly different genotypically. This suggests little or no gene flow between the two areas and that the populations are on different evolutionary trajectories. Perhaps more alarming, they presented preliminary evidence that the Washington population was experiencing reduced genetic variability due to inbreeding.

Studies of greater prairie-chickens in Illinois illustrate the potential consequences when populations decline and become increasingly isolated. The Illinois population of greater prairie-chickens declined from an estimated several million birds distributed over 60 percent of the state during the mid-1800's to 2,000 individuals in 179 subpopulations in 1962 to 46 individuals in two populations by 1994 (Westemeier et al. 1998). The decline occurred despite efforts to improve habitats, control nest parasitism by ring-necked pheasants (*Phasianus colchicus*), and control nest predators. Decreased reproductive performance in the form of lower egg fertility and hatching rate was associated with the contraction and decline of the population (Westemeier et al. 1998). Genetic studies indicated significantly lower levels of genetic diversity in the Illinois population than in larger, more contiguous populations (Bouzat et al. 1998). In an effort to enhance genetic diversity, greater prairie-chickens were translocated to Illinois from Minnesota, Kansas, and Nebraska. Westemeier et al. (1998) predicted the Illinois population would have become extinct had it not been for this intervention.

Reproductive performance

Subadult male sharp-tailed grouse are apt to occupy peripheral territories on the lek and are seldom successful in attracting females for mating (Rippin and Boag 1974a, Moyles and Boag 1981). This does not mean they are not capable of breeding. Nitchuk and Evans (1978) measured the volume of spermatozoa in testes of central and peripheral males collected from large and small dancing grounds in central Manitoba, Canada. They did not report the age of the grouse collected, but it is likely that some of the peripheral males were subadults. All birds (*n* = 74) collected appeared to be physiologically capable of breeding. Hjorth (1970) observed numerous copulations by first-year males when one of the adult central males failed to return to the lek after being trapped. Although first-year males produce viable sperm, evidence indicates their testis volume is smaller than that of adult males (Tsuji et al. 1992). Consequently, they may deliver a lower amount of sperm per ejaculation and are less able to perform multiple copulations than adult males are (Tsuji et al. 1992).

Adult males occupying central territories on the lek perform most copulations. All females apparently breed in their first year after hatch and attempt to lay at least one clutch per nesting season (Connelly et al. 1998). Nesting rates (percent of females that survive

to the nesting season that attempt to nest) reported for CSTG range from 91 to 100 percent (**Table 13**). Meints (1991), McDonald (1998), and Boisvert (2002) concluded that the nesting rate for radio-marked hens in their studies was probably 100 percent, but because some nests were lost during the laying period, some nesting effort went undetected. Most nests of radio-marked hens are found during incubation when the hen spends over 95 percent of her time on the nest. Nests are seldom located during laying because hens spend little time at the nest except to lay an egg. Thus, a hen that loses her clutch during laying is likely to be classified as not attempting to nest. McDonald (1998) reported that these hens often exhibit localized movements typical of hens during the laying period, suggesting they attempted to nest. Attempts to measure nesting rates of CSTG have been based on radio-marked hens initially captured on leks. It is unknown whether there is a non-breeding segment of the female population that does not visit leks to mate and subsequently lay a clutch of eggs.

Both adult and subadult females may lay a replacement clutch (renest) if their first clutch is lost or abandoned (Connelly et al. 1998). Renesting rates (proportion of females that survive their initial nest failure that attempt to renest) vary annually and regionally from less than 20 to over 75 percent (Meints 1991, Apa 1998, McDonald 1998, Boisvert 2002, Collins 2004). Renesting rates in Region 2 (24 to 47 percent) appear to be lower than those reported elsewhere (**Table 13**), with the exception of the 15 percent renesting rate reported by Apa (1998) for southeastern Idaho. Apa (1998) noted he probably failed to detect all renesting attempts because he did not intensively monitor females after they lost their first clutch.

The probability a female will renest is greater if she loses her clutch during laying or early in the incubation period. The probability of laying a replacement clutch also is greater for adult than subadult females (Bergerud 1988a). In northwestern Colorado, 53 percent of 32 adult female CSTG renested compared to only 17 percent of

Table 13. Reproductive parameters of Columbian sharp-tailed grouse in northwestern Colorado (Giesen 1987, Boisvert 2002, Collins 2004), eastern Idaho (Meints 1991), and eastern Washington (McDonald 1998). Sample sizes are in parentheses.

Reproductive parameter	Boisvert (2002)	Collins (2004)	Giesen (1987)	Meints (1991)	McDonald (1998)
Nesting effort, %[1]	98 (62)	98 (121)	—	100 (20)	91 (44)
Renesting effort, %[2]	24 (33)	47 (38)	—	80 (5)	73 (22)
Hen success, %[3]	47 (62)	71 (121)	—	86 (20)	49 (45)
Nest success, %[4]	42 (67)	63 (137)	62 (13)	72 (25)	41 (54)
Nest success, %, initial nest	44 (59)	62 (119)	—	—	41 (37)
Nest success, %, renest	38 (8)	67 (18)	—	—	41 (17)
Clutch size, initial nest	10.2 (39)	10.4 (71)	10.8 (10)	11.9 (19)	12.2 (17)
Clutch size, renest	7.8 (5)	8.5 (11)	—	10.0 (4)	9.5 (10)
Initial clutch size, adult	10.2 (33)	10.4 (60)	—	—	—
Initial clutch size, subadult	10.2 (6)	10.5 (11)	—	—	—
Hatching success, %[5]	91 (367)	94 (835)	—	91 (196)	95 (183)
Egg fertility, %	93 (367)	97 (739)	—	—	—
Brood success, %[6]	76 (28)	58 (79)	—	—	50 (22)
Brood size[7]	4.4 (21)	3.4 (46)	—	4.1 (16)	2.5 (11)

[1] Proportion of females alive at the onset of the nesting season that attempted to nest.

[2] Proportion of females that survived their initial nest failure that attempted to renest.

[3] Proportion of females that hatched at least one egg.

[4] Proportion of nests in which at least one egg hatched. Includes initial nests and renests.

[5] Proportion of eggs in successful nests that hatched.

[6] Proportion of females that successfully nested and still possessed at least one chick at 45 (McDonald 1998) and 49 days (Boisvert 2002, Collins 2004) post-hatch.

[7] Mean brood size at 28 (Meints 1991), 45 (McDonald 1998), and 49 days (Boisvert 2002, Collins 2004) post-hatch. Based on radio-marked females that still possessed chicks at the time counts were conducted.

six subadult females (Collins 2004). Some females will attempt to renest more than once within a single nesting season (Apa 1998, McDonald 1998, Boisvert 2002). Multiple renesting attempts are probably rare within Region 2 because the nesting season is later. Thus, the opportunity for renesting is shorter.

Greater prairie-chickens (means = 8.2 to 12.9 eggs; Schroeder and Robb 1993), lesser prairie-chickens (mean = 10.4 eggs; Giesen 1998), ruffed grouse (means = 9.5 to 11.5 eggs; Rusch et al. 2000), and sharp-tailed grouse (means = 10.9 to 12.3 eggs; Connelly et al. 1998) lay the largest clutches of any North American grouse. Columbian sharp-tailed grouse have the smallest clutch size among the six subspecies of sharp-tailed grouse (Connelly et al. 1998). Populations of CSTG in the southern portion of the range (i.e., Region 2) have smaller clutches than more northern populations. In northwestern Colorado, average clutch sizes for initial nests were 10.2 (Boisvert 2002), 10.4 (Collins 2004), and 10.8 eggs (Giesen 1987) (**Table 13**). In comparison, clutch sizes for initial nests averaged 10.9 eggs in northern Utah (Hart et al. 1950), 11.9 eggs in eastern Idaho (Meints 1991), and 12.2 eggs in eastern Washington (McDonald 1998). This pattern is in accordance with the "egg rule" (Terres 1956), which states that clutch size of many birds increases with increasing latitude.

Within Region 2 (Boisvert 2002, Collins 2004), and elsewhere throughout the range of the CSTG (Meints 1991, McDonald 1998), clutch sizes of initial nests are larger than those of renests by approximately two eggs (**Table 13**). Boisvert (2002) is the only investigator that reported mean clutch size of renests for adult and subadult females. Sample sizes are small, but the data indicate no difference in clutch size of renests between adult (n = 3, mean = 8.0 eggs) and subadult females (n = 2, mean = 7.7).

Numerous investigators have reported estimates of nesting success (proportion of all clutches initiated that hatch at least one egg) for CSTG (Hart et al. 1950, Giesen 1987, Marks and Marks 1987, Meints 1991, Schroeder 1994, Apa 1998, McDonald 1998, Boisvert 2002, Collins 2004). These studies show that nesting success varies among years and among areas within the same year due to differences in weather conditions, age structure of nesting females, and predation rates. Estimates of nesting success range from 37 percent for 110 nests in Utah (Hart et al. 1950) to 72 percent for 25 nests in eastern Idaho (Meints 1991). The combined nest success for 191 nests located by Giesen (1987), Boisvert (2002), and Collins (2004) in Region 2 was

57 percent (range = 42 to 63%; **Table 13**). Apa (1998) reported 51 percent success for 47 nests in southeastern Idaho. Nest success for nine nests in western Idaho was 56 percent (Marks and Marks 1987). Nest success in eastern Washington was estimated by Schroeder (1994) as 60 percent for 10 nests and by McDonald (1998) as 41 percent for 54 nests. McDonald (1998), Boisvert (2002), and Collins (2004) found no difference in nesting success between initial nests and renests (**Table 13**). Collins (2004) also found no difference in nest success between adult (59 percent) and subadult females (56 percent).

Hen success is defined as the proportion of females that hatch at least one egg regardless of the number of nesting attempts. If no hens in a population renest or if all renesting attempts fail, hen success will equal nest success. Since this is rare, estimates of hen success usually exceed estimates of nest success (**Table 13**). In Region 2, of 183 females monitored by Boisvert (2002) and Collins (2004), 115 (63 percent) hatched at least one egg. Generally, if a female successfully incubates a clutch of eggs, the hatching success (proportion of eggs in successful nests that hatch) is high (>90 percent; **Table 13**). Egg fertility also is high (>90 percent; **Table 13**) and typically exceeds hatching success by 2 to 3 percent because infertile eggs are not the only eggs that may fail to hatch in successful nests. In some cases, unhatched eggs are fertile, but the embryos only partially develop. In other cases, the eggs contain fully-developed embryos that failed to hatch or that only partially hatched. This may result from hens leaving the nest before all eggs hatch.

Fledging success is the percent of all eggs laid that produce young surviving to the stage where they become independent of the brood hen (10 to 12 weeks). No studies have measured fledging success for any of the subspecies of sharp-tailed grouse. However, Boisvert (2002) and Collins (2004) calculated brood success (proportion of females that successfully nested that still possessed at least one chick at 7 weeks post-hatch) for CSTG in northwestern Colorado (**Table 13**). The combined estimate of brood success was 63 percent. Approximately 37 percent of all females alive at the onset of the nesting season had at least one chick surviving until mid-August. The total number of chicks counted at seven weeks post-hatch was 248 for an average brood size of 3.7 chicks per successful female or 1.4 chicks per female alive at the onset of the nesting season.

Of 2,066 CSTG wings collected by Giesen (1999) in northwestern Colorado during fall hunting seasons

from 1976 to 1997, 902 (43.7 percent) were classified as adults (includes subadults) and 1,164 (56.3 percent) as juveniles. This equates to 1.3 juveniles per adult in the fall harvest. Based on gonadal inspection of 93 adults in the fall harvest, Giesen (1999) estimated that 54.8 percent were females. Thus, of the 902 wings classified as adults, approximately 494 should have been females. Therefore, the juvenile per female ratio was 2.4. This exceeds the estimate of 1.4 juveniles per female in mid-August using data collected by Boisvert (2002) and Collins (2004) in northwestern Colorado. It is possible that harvest samples do not accurately reflect the composition of the population or that Boisvert (2002) and Collins (2004) under-estimated brood sizes.

Survivorship

Ammann (1957) estimated the average lifespan for prairie sharp-tailed grouse in Michigan as 1.6 years for males and 1.5 years for females. Individuals over five years of age were rare. The oldest known grouse was a male that was at least 7.5 years old when it was shot. Hamerstrom and Hamerstrom (1951) reported the oldest known age for a sharp-tailed grouse in Wisconsin was 4.5 years. Five years was the longest any banded plains sharp-tailed grouse in South Dakota was recaptured or recovered following its capture (Robel et al. 1972). Survival data for greater prairie-chickens and plains sharp-tailed grouse in Nebraska indicated few grouse lived past two to three years of age (Sisson 1976). Of 41 banded grouse for which age at death was known, 90 percent were less than three years of age and the oldest was between five and six years of age (Sisson 1976).

Longevity data for CSTG are lacking because there have been no long-term (over four years) studies of this subspecies. Collins (2004) monitored two radio-marked females through three consecutive nesting seasons. Both females were captured on leks in spring as adults (at least two years of age). Thus, they were at least five years old entering their third nesting season.

Annual survival estimates for radio-marked CSTG vary from a low of 20 percent to a high of 55 percent (**Table 14**). This is comparable to annual survival rates reported for prairie sharp-tailed grouse in Michigan (40 percent; Ammann 1957) and plains sharp-tailed grouse in South Dakota (21 to 30 percent; Robel et al. 1972) and Nebraska (31 percent; Sisson 1976). Data collected by Ammann (1957) suggested that female prairie sharp-tailed grouse had slightly lower survival than males did. For CSTG, neither Boisvert (2002) nor Collins (2004) documented any difference in annual survival by gender, whereas McDonald (1998) reported lower annual survival among males than females.

In eastern Washington, survival of males and females did not differ between seasons on one study area, but on another area, female survival was lower during spring-summer than fall-winter (McDonald 1998). Overall, McDonald's (1998) data indicated the combined survival of males and females was lower during spring-summer (55 to 77 percent) than fall-winter (80 to 86 percent), with the lowest survival occurring during June. Survival of nesting hens (89 percent) during the incubation period was no different than for hens not engaged in nesting (96 percent). However, for the 21-day period following hatching, females with broods had lower survival (81 percent) than females without broods (97 percent). The probability that a nesting hen would survive the incubation period and, if successful, survive the initial 21-day brood-rearing period was 73 percent compared to 94 percent for females not engaged in nesting or brood-rearing.

In southeastern Idaho, Ulliman (1995b) reported that habitat use patterns and survival differed under severe and mild winter conditions. During the mild winter of 1991–92, first snowfall was in late December, maximum snow depth was 12.7 cm, and complete snowmelt in the valleys occurred by 18 February. Radio-marked grouse used CRP fields and sagebrush cover types more than expected, and survival was 86 percent (n =14) from late December to mid-March.

Table 14. Annual survival estimates of Columbian sharp-tailed grouse.

Annual survival (%)	Location	Source (basis)
20 (n = 61)	Northwestern Colorado	Boisvert 2002 (telemetry)
33 (n = 96)	Northwestern Colorado	Collins 2004 (telemetry)
45 (n = 100)	Northwestern Colorado	Collins 2004 (telemetry)
42 (n = 927)	Northwestern Colorado	Giesen 1987 (harvest samples)
53 (n = 41)	Eastern Washington	Schroeder 1994 (telemetry)
55 (n = 38)	Eastern Washington	McDonald 1998 (telemetry)

During the more severe winter of 1992-93, snowfall began in November, maximum snow depth was 45.7 cm, and complete snowmelt did not occur until 26 March. Radio-marked grouse used riparian shrub cover types more than expected and survival was only 29 percent ($n = 14$) from late December to mid-March.

Boisvert (2002) reported that seasonal survival of CSTG in northwestern Colorado was greatest during summer/brood-rearing, fall, and winter, and lowest during breeding and nesting (**Table 15**). Survival was lower during the nesting season than in summer, fall, and winter in both years of study, and lower during the breeding season compared to summer, fall, and winter in 2000. Boisvert (2002) conducted a proportional hazards analysis on seven covariates, including age, gender, and habitat use, potentially influencing survival time of CSTG during the spring through fall period when they are in breeding areas. The most significant variable predicting time of survival was proportional use of CRP followed by proportional use of shrubsteppe. Columbian sharp-tailed grouse using grass and mine reclamation cover types had the lowest hazard ratios. Compared to CSTG using mine reclamation, grouse using CRP and shrubsteppe were 11.1 and 8.7 times more likely to die.

Collins (2004) reported that during the period when grouse are in breeding areas (April to October), survival of females using the shrubsteppe cover type (55 percent) did not differ from survival of females using mine reclamation (51 percent). Within cover types, survival did not differ among seasons for female grouse using mine reclamation (**Table 15**). For females

using shrubsteppe, survival in 2001-2002 was greater during the breeding season than during the summer and winter seasons. Survival in 2002-2003 was higher during the nesting season compared to the summer and fall seasons. Comparisons between cover types indicated that females using mine reclamation had higher survival during summer (brood-rearing) and winter than females using shrubsteppe, which had higher survival than females using mine reclamation during the breeding season. Comparisons by gender showed males had higher survival than females during the nesting, brood-rearing, and fall seasons. Survival of males was lower than females during the breeding season, but the difference was not significant.

McDonald (1998) estimated survival until 45 days post-hatch was only 12 percent for 243 chicks on two different study areas in eastern Washington. Boisvert (2002) monitored 28 broods in northwestern Colorado from time of hatch until seven weeks post hatch during 1999 ($n = 14$) and 2000 ($n = 14$). Estimated chick survival was 49 (1999) and 47 percent (2000). Over two years of moderate (2001) to severe (2002) drought conditions in northwestern Colorado, estimated survival of 785 chicks until seven weeks post-hatch was 20 percent (Collins 2004). Survival of 677 chicks in broods of adult females was 23 percent compared to 9 percent survival for 108 chicks in broods of subadult females (Collins 2004). Within the shrubsteppe cover type, chick survival did not differ between years (2001= 13%, 2002 = 14%). In mine reclamation, chick survival during the moderate drought year (2001 = 45%) was significantly greater than survival (2002 = 20%)

Table 15. Seasonal survival estimates of Columbian sharp-tailed grouse in northwestern Colorado (Boisvert 2002, Collins 2004).

Source	Breeding	Nesting	Summer[1]	Fall	Winter
Boisvert (2002)[2]					
1999	77	77	93	90	82
2000	78	78	87	93	87[3]
Collins (2004)[4]					
2001 MR females	73	75	94	84	70
2001 SS females	100	86	80	83	44
2002 MR females	86	92	76	84	76
2002 SS females	96	100	78	77	83
2002 MR males	68	100	100	100	66

[1] Includes brood-rearing season.

[2] Data includes males and females combined.

[3] Study terminated before the winter period ended.

[4] Survival estimated by cover type (MR = mine reclamation, SS = shrubsteppe) and by gender for females in both years and males in 2002 only for the MR cover type. Sample sizes for males in the SS cover type were inadequate to estimate survival.

during the severe drought year. Chick survival in mine reclamation was greater than in shrubsteppe during the moderate drought in 2001 but not during the severe drought in 2002.

Population model

Matrix demographic models facilitate assessment of critical transitions in the life history of an animal. The first step is to create a life cycle graph from which to compute a projection matrix amenable to quantitative analysis using computer software (Caswell 2001). A stage-classified life cycle graph was constructed for CSTG that had two stages (**Figure 7**), first-year and adult females (second year and older). From the life cycle graph, a matrix population analysis was conducted assuming a birth-pulse population with a 1-year census interval and a post-breeding census (McDonald and
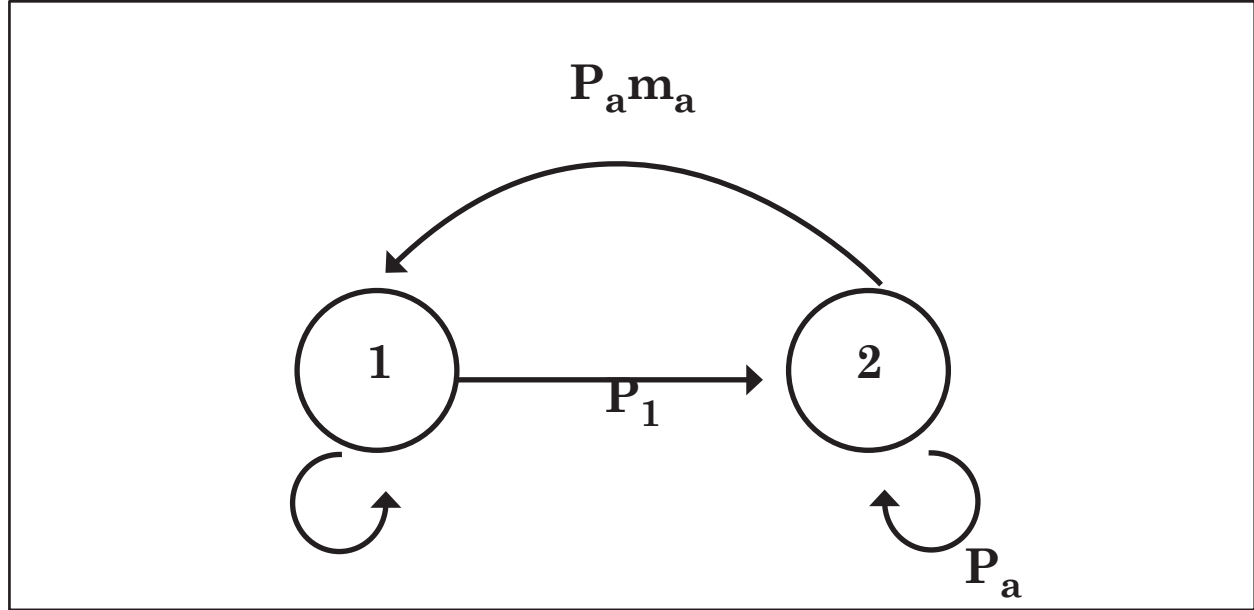
Figure 7. Life cycle graph for Columbian sharp-tailed grouse. The numbered circles (nodes) represent the two stages (first year females = node 1, adult females = node 2). The arrows (arcs) connecting the nodes represent the vital rates (transitions between stages, survival or fertility). The horizontal arc describes survival rates (P_1). The arc that points from node 2 to node 1 describes fertility (e.g., $P_a * m_a$). The self-loop on node 1 denotes fertility of first-year birds at the end of their first year (i.e., as yearlings), following their survival (P_1) through a one-year interval from censusing as chicks to just before they are censused again at the start of their second year of life. The self-loop on node 2 represents the (constant) annual probability of survival for adult females. Each of the arcs corresponds to a cell in the matrix of **Figure 8**.

(A)

Stage	1	2
1	$P_1 * m_1$	$P_a * m_a$
2	P_1	P_a

(B)

Stage	1	2
1	0.243	0.426
2	0.352	0.441

(C)

Stage	1	2
1	0.341	0.596
2	0.493	0.617

(D)

Stage	1	2
1	0.513	0.898
2	0.352	0.441

(E)

Stage	1	2
1	0.436	0.763
2	0.414	0.518

Figure 8. Matrix of vital rates corresponding to the Columbian sharp-tailed grouse life cycle graph (**Figure 7**). (A) Symbolic values for the cells of the projection matrix; (B) numeric values for the "face-value" model; (C) numeric values for the stationary model with survival adjusted upwards; (D) numeric values for the stationary model with chick production adjusted upwards; and (E) numeric values for the stationary model with survival and chick production adjusted upwards.

Caswell 1993, Caswell 2001). The breeding pulse comes at the end of each 1-year census interval. All calculations used *Mathematica*™ programs written by D. B. McDonald at the University of Wyoming, mostly following algorithms in Caswell (2001).

Four different models were constructed. One model used the available demographic data (vital rates) at "face value" and three "stationary" models used adjustments of the vital rates to arrive at a population growth rate (λ) close to 1.0. The demographic term for a population that is neither growing nor decreasing in size is a "stationary" population. For the face value model, the following criteria were used to estimate vital rates.

❖ Number of fledgling females per female (0.84) was calculated based on data collected by Boisvert (2002) and Collins (2004).

❖ Survival was based on a "best estimate" value of 0.40 over all age classes. Because few data were available, a preliminary estimate of first-year survival was set at 80 percent of the adult level. Survival estimates were estimated based on a proportion of 0.56 adults and 0.44 first-year birds from an initial assessment of the stable stage distribution. These assumptions led to a first-year survival rate of 0.352 and an adult survival rate of 0.441.

❖ The available data yielded an overall estimate of 0.84 female chicks raised to the 7-week stage per female. Based on data for differential success of first-year birds, their success was set at 71.4 percent of that of adult birds. Using the age ratio of 0.56 adults and 0.44 first-year birds produced an estimate of 0.967 female chicks for adult females and 0.691 female chicks for first-year females.

For the "stationary models", the following criteria were used to estimate vital rates.

❖ Survival adjusted upward. Overall survival was adjusted upward to 0.56, yielding a population growth rate (λ) of 1.04. A deterministic growth rate slightly higher than 1.0 was used because it provides a buffer against the detrimental and inevitable effects of variation in the vital rates due to environmental stochasticity.

❖ Chick production adjusted upward. Chick production was set at 1.77, yielding a λ of 1.04.

❖ Survival and chick production adjusted upward. Survival was adjusted upward to 0.47 and chick production to 1.28, yielding a λ of 1.04.

All models assumed female demographic dominance so that fertilities are given as female fledglings per female. Thus, the fledgling number used was half the total annual production of fledglings assuming a 1:1 sex ratio. The models had two input terms: P_i describing survival rates, and m_i describing fertility (**Table 16**). The symbolic terms in the projection matrix corresponding to the life cycle graph and the numeric values for the face-value and three stationary models are shown in **Figure 8**. The fertility terms in the top row of the matrix includes a term for offspring production (m_i), as well as a term for the survival of the mother (P_i) from the census (just after the breeding season) to the next birth pulse almost a year later.

The face value model yielded a population growth rate (λ) of 0.742, indicating an annual and unsustainable decline of 35.8 percent. This estimate is probably the result of imprecise data and should not be interpreted

Table 16. Vital rates for the face value and stationary matrix projection models. Only the rates that differ from the face value model are shown for the stationary models with adjusted vital rates.

Vital rate	Description	Face value	Stationary ($\lambda = 1.04$)[1]		
			Model 1	Model 2	Model 3
m_1	Chicks per first-year female	0.69		1.46	1.05
m_a	Chicks per adult female	0.97		2.04	1.47
P_1	Female chicks per first-year female	0.35	0.49		0.41
P_a	Female chicks per adult female	0.44	0.62		0.52

[1]Model 1 survival adjusted upwards; model 2 chick production adjusted upward; model 3 both survival and production adjusted upwards.

as an indication of the general well-being or stability of the population. Likewise, λ for the stationary models does not accurately reflect what is happening in the real population. It was set at 1.04 only as a target towards which to adjust the vital rates. The modeling exercise indicated that more detailed and long-term population data are needed to have any confidence in the estimation of λ. Despite limitations, the models provide a basis using sensitivity and elasticity analyses for assessing the relative vulnerability of portions of the life cycle when considering management of CSTG.

Sensitivity is the effect on λ of an absolute change in the vital rates (i.e., survival and fertility). Sensitivity analysis provides useful information about the state of the population (Caswell 2001).

❖ Sensitivities show how important a given vital rate is to λ and can be a useful integrative measure of overall fitness.

❖ Sensitivities can be used to evaluate the effects of inaccurate estimation of vital rates from field studies.

❖ Sensitivities can quantify the effects of environmental perturbations wherever those can be linked to effects on age-specific survival or fertility rates.

❖ Sensitivities allow researchers to identify and focus their efforts on the vital rates in most need of study.

For the face value and survival-adjusted models (**Figure 9**), λ was most sensitive to changes in adult survival (32 percent of total sensitivity) closely followed by first-year survival (27 percent of total sensitivity). Under the fertility-adjusted model and the model where fertility and survival were adjusted (**Figure 9**), λ was most sensitive to changes in first-year survival (38 percent of total sensitivity). The sensitivity analysis suggests that survival rates are most important to population viability.

Elasticities are useful in resolving a problem of scale that can affect conclusions drawn from sensitivity analysis. Interpreting sensitivities can be misleading because survival and reproductive rates are measured on different scales. Elasticities are the sensitivities of λ to proportional changes in vital rates. Elasticities partly avoid the problem of differences in units of measurement associated with sensitivity estimates and have the useful property of summing to 1.0. The difference between conclusions of elasticity and sensitivity analyses result from weighting of elasticities by the value of the original vital rates. Management conclusions will depend on whether the changes in vital rates are likely to be absolute (guided by sensitivities) or proportional (guided by elasticities). By using elasticities, one can further assess key life history transitions and stages as well as the relative importance of reproduction and survival for a population. It is important to note that elasticity and sensitivity analysis assume the magnitude of the changes (perturbations) to the vital rates is small. Large changes require a reformulated matrix and reanalysis.

Under the face value and survival-adjusted models (**Figure 10**), the λ of CSTG was most elastic to changes in adult survival (37 percent of total elasticity). For the fertility-adjusted model and the model in which fertility and survival were adjusted (**Figure 10**), λ was equally and most elastic to first-year survival and adult fertility

(A) Stage	1	2	(B) Stage	1	2
1	0.377	0.441	1	0.532	0.313
2	0.533	0.623	2	0.796	0.468

Figure 9. Sensitivity matrix for (A) the face value model with λ = 0.742 and (B) for the fertility-adjusted stationary model with λ = 1.04. Sensitivities for the survival adjusted model and the fertility and survival-adjusted model are not shown because the values are nearly the same as for the face value and fertility-adjusted models, respectively.

(A) Stage	1	2	(B) Stage	1	2
1	0.124	0.253	1	0.262	0.27
2	0.253	0.37	2	0.27	0.198

Figure 10. Elasticity matrix for (A) the face value model and (B) the fertility-adjusted stationary model. Sensitivities for the survival adjusted model and the fertility and survival-adjusted model are not shown because the values are nearly the same as for the face value and fertility-adjusted models, respectively.

(each accounted for 27 percent of total elasticity). Nearly as important was first-year fertility (26 percent of total). Caswell (2001) suggests that when the elasticities and sensitivities are relatively evenly apportioned across the life history, populations should be somewhat robust to environmental variability. This seems to be the case for CSTG based on the low differences between the highest and lowest elasticity and sensitivity values (**Figure 9**, **Figure 10**).

The stable stage distribution describes the proportion of each stage or age class in a population at demographic equilibrium. Under a deterministic model, any unchanging matrix will converge on a population structure that follows the stable stage distribution regardless of whether the population is declining, stationary, or increasing. Populations not at equilibrium will usually converge to the stable stage distribution in 20 to 100 census intervals. For CSTG at the time of the post-breeding annual census (just after the end of the breeding season), the population at stable stage distribution should consist of 46 percent chicks and 54 percent adults.

Reproductive values can be considered as describing the "value" of a stage as a seed for population growth relative to that of the first (newborn or, in this case, fledgling) stage (Caswell 2001). The reproductive value is calculated as a weighted sum of the present and future reproductive output of a stage discounted by the probability of surviving (Williams 1966). The reproductive value of the first stage is, by definition, always 1.0. For CSTG, an adult female is worth 1.41 fledglings. The estimated cohort generation time for CSTG ranged from 1.9 years under the face value model to a high of 2.8 years under the survival-adjusted model. The implicit time steps in the matrix model allow one to calculate the mean and variance of ages of individuals in mixed-age stages (i.e., adults). For the face value model, the mean age of adult females was 2.5 years (SD = 1.9).

Improved estimates of survival and fertilities from Region 2 are required to refine the models and increase the relevance and accuracy of the analysis. The present analysis is only a guide to the forces acting on the demography of CSTG in Region 2. Data from natural populations on the range of variability in the vital rates would allow modeling of stochastic fluctuations. Other potential refinements include incorporating density-dependent effects. Presently, the data appear insufficient to assess reasonable functions governing density dependence.

There are seven major conclusions from the matrix projection model.

1. The primary reason for developing the matrix model was to assess critical stages in the life history of CSTG rather than to make predictions about population growth rate, population viability, or time to extinction. Insufficient data are available to make such predictions. Because data are limited, the model provides preliminary guidance on which vital rates should be the focus of future research efforts.

2. Survival accounted for approximately 60 percent of the total possible sensitivity in all models examined.

3. Survival was important to the elasticity (62 percent) of the population growth rate in two of the four models examined. In the other two models, survival (47 percent) and fertility (53 percent) were of nearly equal importance.

4. No clear pattern emerged with regards to age class (first-year and adult females) concerning the importance of fertility and survival to the population growth rate. For the face value and survival-adjusted models, adult survival appeared slightly more important to the sensitivity (32 percent) and elasticity (37 percent) of the population growth rate. In contrast, first-year survival was most important in the sensitivity analysis (36 percent) for the fertility-adjusted model and the model where fertility and survival were both adjusted.

5. Overall, the importance of the different vital rates as assessed by either the elasticity or sensitivity analysis were relatively even, suggesting that management activities that increase any of the vital rates will have a beneficial impact on population growth rate.

6. The difference between the face value vital rates and those required to maintain a stationary population indicate that fertility, survival, or both are underestimated based on the studies by Boisvert (2002) and Collins (2004) in Region 2. The estimated survival rates used in the face value model would need to increase from 0.35 to 0.49 for

first-year females and 0.44 to 0.62 for adult females to yield a stationary growth rate of 1.04, which allows for the dampening effects of variability in vital rates.

7. Another possibility is that serious declines are actually occurring in the population, but lek count data do not support this possibility. Although the counts have declined in recent years, the decline has not been as serious as the population growth rate ($\lambda = 0.742$, annual decline = 36 percent) calculated from the face value model implies.

Population regulation

Some researchers have proposed that size of breeding populations of grouse may be self-regulated through intrinsic factors, such as spacing behavior (Hannon 1988). For example, aggressive behavior by dominant females on the lek may result in delayed breeding of subordinate females, or at the extreme, prevent some females from breeding. Delays in breeding and hence nest initiation may affect an individual female's fitness because there would be less time for renesting. In addition, nests initiated later may be less successful. Robel (1970) suggested this type of behavior may occur in greater prairie-chickens. No data are available to indicate some female CSTG do not breed and subsequently attempt to nest or that nests initiated later are less successful than nests initiated early (Meints 1991, Apa 1998, McDonald 1998, Boisvert 2002, Collins 2004). If there are females that do not visit leks and presumably do not breed, they would not have been detected in these studies because only females that visited leks were captured and monitored for nesting activity. Thus, the role of female-female interactions in controlling productivity in CSTG remains unknown.

Other researchers have suggested that extrinsic factors (e.g., weather, disease, habitat, predation), either singly or in combination, influence the size of grouse breeding populations through their impact on reproduction and survival (Angelstam 1988). Connelly et al. (1998) noted that few data have been collected regarding population regulation in sharp-tailed grouse, but they cited information summarized by Bergerud (1988a) as indicating size of sharp-tailed grouse breeding populations may be correlated with annual reproductive success the preceding year (expressed as chicks per female in the fall population). The number of juveniles raised to independence per adult is a key demographic parameter in the dynamics of any grouse population. This parameter is influenced by clutch size, percentage of females nesting, renesting rates, nesting success, hatching success, and subsequent survival of juveniles to independence. Because sharp-tailed grouse have naturally high mortality rates, correspondingly high reproductive rates are essential for maintaining population stability. Numerous factors can affect reproductive success of sharp-tailed grouse, but vegetation cover (Kirsch et al. 1978) and weather (Flanders-Wanner et al. 2004) are considered most important. These two factors are not mutually exclusive. Instead, they interact as part of a complex ecological relationship between grouse and the environment to influence productivity.

In north-central Nebraska, Flanders-Wanner (2004) found that May average temperature, June average temperature, and cumulative precipitation from 1 January to 31 July (drought index) were positively correlated with plains sharp-tailed grouse production (juveniles per adult in the fall harvest); conversely, June number of heat stress days and June number of days of precipitation greater than 2.54 mm were negatively correlated with production. The most valuable predictor of productivity was the drought index, although the relationship was not straightforward. Productivity was influenced by both amount and timing of precipitation as illustrated by the fact that productivity was positively correlated with the drought index, but negatively correlated with June total precipitation. Adequate precipitation enhances vegetative growth, which in turn provides better cover for nesting and brood-rearing and more food (plants and insects) for chicks. However, if too much moisture occurs in June, especially immediately following the peak of hatch, production may be lower due to chilling of young chicks.

The controversy over what influences stability in grouse populations continues between those who argue that control occurs through intrinsic factors and those who argue control occurs through extrinsic factors. More recently, biologists are attempting to describe how intrinsic and extrinsic factors interact to regulate populations (Watson et al. 1998). Despite several long-term studies of grouse (reviewed by Boag and Schroeder 1992, Zwickel 1992, Braun et al. 1993, Schroeder and Robb 1993), the exact mechanisms of population regulation remain unclear and continue to be a subject of debate among biologists. In addition, as habitats become more fragmented and degraded, factors influencing population stability may change. Factors normally not considered as regulating healthy

populations, such as predation, disease, and hunting, may have greater influence on small, fragmented populations existing in substandard habitats.

Community ecology

Predation

Grouse die from many causes including accidents, disease, starvation, hunting, and predation. Of these causes, predation accounts for over 85 percent of all reported mortalities in grouse (Bergerud 1988a). Biologically, it has long been understood that the ultimate fate of most grouse is to be depredated and eaten by some predator. For this reason, predation is a major force in shaping the dynamics of grouse populations (Bergerud 1988a, Reynolds et al. 1988, Hewitt et al. 2001, Schroeder and Baydack 2001).

The contention of most biologists is that predation is not a factor limiting grouse populations, provided suitable habitat is available. Grouse have evolved with predators and have developed strategies to compensate for high predation rates. However, in many areas, human activities have drastically altered the landscape and possibly disrupted the balance between predators and prey in ways that favor certain predators. The extent to which human activities have influenced predation rates on CSTG has yet to be measured, but it is likely that human-related factors have contributed to an increase in some predator populations, allowed other predators to expand their range, and improved the hunting efficiency of still other predators. For example, within the range of CSTG, humans have provided mammalian predators such as common raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), and red fox (*Vulpes vulpes*) travel corridors (e.g., roads, irrigation ditches, rural developments), more diverse food supplies (e.g., grain, garbage, road kills, domestic poultry), and more places to over-winter and rear young (e.g., abandoned buildings, haystacks, barns). Humans also have provided avian predators such as common ravens (*Corvus corax*), American crows (*C. brachyrhynchos*), golden eagles (*Aquila chysaetos*), and great horned owls (*Bubo virginianus*) with more places to nest and perch in the form of trees planted by humans and artificial structures built by humans.

Ascertaining cause-specific (e.g., mammalian or avian) mortality of grouse is difficult (Lariviere 1999, Bumann and Stauffer 2002). Identifying the specific predator is even more challenging, especially for species such as sharp-tailed grouse that have a large suite of predators. The list of potential predators of CSTG in Region 2 include Cooper's hawk (*Accipiter cooperii*), great horned owl, golden eagle, northern harrier (*Circus cyaneus*), prairie falcon (*Falco mexicanus*), red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*B. swainsoni*), northern goshawk (*A. gentilis*), ferruginous hawk (*B. regalis*), common raven, western rattlesnake (*Crotalus viridis*), coyote (*Canis latrans*), red fox, bobcat (*Felis rufus*), weasel (*Mustela* spp.), and American badger (*Taxidea taxus*). Some of these predators take grouse year-round. Others only take grouse at certain times of the year. Still others may only prey on young grouse.

Of 15 mortalities in Utah for which a cause could be assigned, Hart et al. (1950) attributed 7 and 93 percent to avian and mammalian predators, respectively. Hart et al. (1950) specifically mention observing coyotes making successful and unsuccessful attempts to catch grouse on leks, and they provided evidence of several grouse that were attacked and killed by weasels. Hart et al. (1950) also mention California gulls (*Larus californicus*) as a potential predator of sharp-tailed grouse eggs and young. Flocks of gulls were commonly observed in alfalfa fields used by CSTG for feeding and nesting. Hart et al. (1950) speculated that gulls would prey on the eggs and young of CSTG given the opportunity. In support of this contention, Hart et al. (1950) referred to McAtee (1945) who reported California gulls preying on pheasant chicks.

In southeastern Idaho, Parker (1970) reported finding the remains of three adult CSTG in the nest of a rough-legged hawk (*Buteo lagopus*). This may be a case of misidentification. The nest was more likely that of a ferruginous hawk. Marks and Marks (1987) reported that avian predators accounted for 19 (86 percent) of 22 mortalities of CSTG in western Idaho where cause of death was ascertained. On two occasions, they flushed northern goshawks from freshly killed radio-marked male CSTG. They also found evidence of a golden eagle and great horned owl at two other mortality sites. Meints (1991) listed the fate of 48 CSTG captured and radio-marked on leks in eastern Idaho. Seven were shot, three were found dead of unknown causes, two were killed by mammalian predators, seven were killed by avian predators, and the fate of the remaining 32 grouse was unknown. Excluding hunting, seven (78 percent) of the nine known causes of death were attributed to avian predators. McDonald (1998) reported that avian predators appeared to be responsible for the majority of CSTG mortalities in eastern Washington, but did not provide any numerical estimates of predation rates. Coates (2001) found mammalian, avian, and unknown predation accounted for 51, 28, and 21 percent,

respectively, of 43 mortalities of transplanted CSTG in northern Nevada.

Boisvert (2002) documented 110 mortalities of CSTG in northwestern Colorado. Cause of death was reported as mammalian predators (41 percent), avian predators (33 percent), crop impaction possibly due to the radio-transmitters (4 percent), hunting (2 percent), natural mortality (2 percent, no cause given), and unknown (18 percent). Known predators of grouse in this study based on observed kills or recovery of radios were golden eagle, prairie falcon, red-tailed hawk, great horned owl, red fox, and bobcat.

Collins (2004) monitored the fate of 172 radio-marked grouse in northwestern Colorado, of which 114 were eventually found dead. Mammals were responsible for 33 percent of all deaths, avian predators accounted for 19 percent, and radio-collars for 2 percent. The remaining deaths (46 percent) were from unknown causes. Two radio-transmitters were recovered from a golden eagle nest, one from a great horned owl nest, and one from a red-tailed hawk nest. Other raptors observed at fresh kill sites included northern goshawk and Cooper's hawk. Two grouse were known to be killed by bobcats. Grouse using mine reclamation (i.e., grassland) were killed more often by avian predators, and grouse using shrubsteppe were killed more often by mammalian predators.

Most of the known mammalian predators also eat eggs of sharp-tailed grouse. Additional nest predators include striped skunk, bull snake (*Pituophis melanoleucus*), common raccoon, common raven, American crow, American magpie (*Pica hudsonia*), Richardson's ground squirrel (*Spermophilus richardsoni*), and porcupine (*Erethizon dorsatum*). Based on evidence found at the nest, McDonald (1998) concluded that common ravens and coyotes depredated the majority of unsuccessful CSTG nests in eastern Washington. In northwestern Colorado, Collins (2004) attributed 56 percent of 36 nest depredations to mammals, 6 percent to avian predators, and 38 percent to unknown predators. In a companion study of greater sage-grouse, Hausleitner (2003) reported similar findings with mammals accounting for 70 percent and birds only 5 percent of 40 nest depredations. Collins (2004) suspected two nests were destroyed by skunks, one by a bobcat, and at least 14 by coyotes or red fox.

Six of the 14 nest depredations for which Collins (2004) was unable to identify the predator involved disappearance of the entire clutch with no signs of disturbance at the nest. In no instance was the female killed. Collins (2004) suspected that snakes and/or ravens were responsible for these losses. Davison and Bollinger (2000) noted that snakes are major nest predators in grassland and shrubland cover types, but their importance as nest predators is often under-estimated. Thompson et al. (1999) documented that 88 percent of songbird nests depredated by snakes showed no signs of disturbance. Recent research using videography indicated that ravens were responsible for the disappearance of entire clutches at greater sage-grouse nests (P.S. Coates personal communication 2006). If this is also true for CSTG, then Collins (2004) under-estimated the proportion of nests depredated by avian predators.

Although nest predation rates are high, few hens are killed on the nest. Summarizing telemetry data from several studies, Bergerud and Gratson (1988) estimated 4 percent of female sharp-tailed grouse are killed on the nest. McDonald (1998) reported only two (3.7 percent) of 54 nesting attempts by CSTG resulted in the hen being killed on the nest. Coates (2001) reported that only one (5 percent) of 19 nesting hens in a transplanted population died during incubation. It was not clear whether this hen was killed on or off the nest. Of 121 nesting attempts documented by Collins (2004) in northwestern Colorado, four hens were killed away from the nest, one hen was killed by a raptor immediately adjacent to the nest, and one hen was killed on the nest.

The response of CSTG to predators varies. Sharp-tailed grouse will crouch and hide, remain motionless, fly, or run, depending on the type of predator, its closeness, and its activity (Connelly et al. 1998). Female sharp-tailed grouse will perform distraction displays by feigning injury to lure predators away from their young (Artmann 1970). When on the lek, sharp-tailed grouse are more likely to fly to escape cover in response to predators, then crouch and hide. Prairie grouse on leks tend to react more strongly to avian than mammalian predators (Berger et al. 1963, Hamerstrom et al. 1965, Sparling and Svedarsky 1978). When off the lek, the first response to predators is usually to crouch and hide and only fly if pursued.

In some cases, both on and off the lek, sharp-tailed grouse show no reaction to predators because the predator presents no immediate threat. In five encounters with male northern harriers on leks in Minnesota, sharp-tailed grouse responded once by all birds flushing from the lek, once by all birds crouching on the lek, and three times by some birds flushing from the lek (Sparling and Svedarsky 1978). In nine encounters with female

northern harriers, six resulted in all the birds flushing from the lek, one resulted in all the birds crouching on the lek, and two resulted in little or no reaction (Sparling and Svedarsky 1978). In the only documented encounter with a red-tailed hawk, all the birds flushed. Columbian sharp-tailed grouse on leks in Colorado seldom flushed in response to northern harriers unless the harrier flew directly over the lek and swooped at the grouse (R.W. Hoffman personal observation). In contrast, the appearance of a golden eagle anywhere near the lek caused the grouse to flush.

Competition

Gunnison sage-grouse, greater sage-grouse, dusky grouse, ruffed grouse, ring-necked pheasant, gray partridge (*Perdix perdix*), chukar (*Alectoris chukar*), California quail (*Callipepla californica*), and wild turkey (*Meleagris gallopavo*) are gallinaceous birds with distributions that may overlap the range of CSTG at certain times of the year. It is unknown whether CSTG directly or indirectly compete for resources with any of these species. The species most likely to encounter CSTG due to similar habitat requirements include Gunnison sage-grouse, greater sage-grouse, dusky grouse, ring-necked pheasant, and gray partridge. Of these, only Gunnison sage-grouse, greater sage-grouse, and dusky grouse occur within the range of CSTG in Region 2. Nowhere does the CSTG occur in close proximity to the congeneric greater and lesser prairie-chickens.

The range of the CSTG in Region 2 overlaps the upper limit of Gunnison and greater sage-grouse and lower limit of dusky grouse. If competition does occur, it occurs during the breeding, nesting, and brood-rearing periods when the four species may be using similar habitats and eating the same foods. Competition during winter is unlikely because sage-grouse and dusky grouse in Region 2 occupy different habitats and eat different foods than CSTG at this time of year. Even where CSTG use the same habitats as sage-grouse and dusky grouse, the likelihood of significant competition should be low because the different species evolved together and should partition habitats to minimize competition. Apa (1998) provided some evidence in support of this contention. In the only study that specifically examined niche overlap between CSTG and another sympatric grouse species, Apa (1998) reported that greater sage-grouse and CSTG in southeastern Idaho partitioned nesting habitat. There also appeared to be some niche separation in brood habitat, but not to the same extent exhibited with nest sites (Apa 1998).

Nest parasitism by ring-necked pheasants on greater prairie-chicken nests is known to occur where the two species are sympatric (Vance and Westemeier 1979). The average incubation period for ring-necked pheasants is shorter than for prairie-chickens or sharp-tailed grouse. Parasitized nests are known to contribute to the failure of greater-prairie chicken nests as the female will leave the nest with pheasant chicks before her own eggs hatch (Vance and Westemeier 1979). Columbian sharp-tailed grouse are sympatric with ring-necked pheasants in some portions of Utah, Idaho, and Washington. No instances of nest parasitism have been reported from studies of nesting sharp-tailed grouse in these states (Hart et al. 1950, Meints 1991, Schroeder 1994, Apa 1998, McDonald 1998). The probability of nest parasitism may be lower for CSTG than it is for greater prairie-chickens for several reasons. Nesting habitats of CSTG may differ from that preferred by pheasants, pheasant densities may be lower where they are sympatric with CSTG, or the timing of breeding and nesting activities may differ between pheasants and CSTG where they occur together. Reduced availability of native nesting habitats for CSTG may cause them to use cover types frequented by pheasants, such as CRP. This may increase the probability of nest parasitism.

No wild populations of ring-necked pheasants occur within the range of CSTG in Region 2, but another exotic species known to parasitize nests, the gray partridge, may eventually expand its range into south-central Wyoming and northwestern Colorado. This species has been expanding its range southward in Wyoming. Documented observations south of Interstate 80 near Rawlins, Wyoming place it within 56 to 64 km of the northern distribution of CSTG in Wyoming.

Mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), and pronghorn (*Antilocapra americana*) are common and extremely abundant in localized areas throughout the range of CSTG in Region 2. The spring through fall range of CSTG primarily coincides with the spring and summer range of pronghorn and transitional range (early spring and late fall) of mule deer and elk. The largest concentration of grouse and wild ungulates together occurs from early-April to early-May when grouse are attending leks. With the possible exception of elk, few wild ungulates share the same range with CSTG during winter in Region 2. However, mule deer and elk use the winter range of CSTG from late spring through summer and fall and into early winter depending on snow conditions. The extent to which CSTG compete with wild ungulates for resources (mainly food) is unknown. Food habit studies

of mule deer (reviewed by Wallmo and Regelin 1981), elk (reviewed by Cook 2002), and pronghorn (reviewed by Yoakum 2004) indicate that they consume some of the same foods as CSTG, suggesting competition may occur. Braun et al. (1991) hypothesized that heavy use of willow by elk in Rocky Mountain National Park may constrain breeding densities of white-tailed ptarmigan by reducing the amount of food available to ptarmigan in late winter. Ulliman (1995b) suggested that a relationship similar to the one reported by Braun et al. (1991) could occur in southeastern Idaho among mule deer, CSTG, and serviceberry. In Region 2, the impacts of elk also must be factored into this relationship. Clearly, more research is needed to document whether such a relationship exists.

Parasites and disease

Sharp-tailed grouse are hosts to parasitic arthropods (e.g., lice, mites, ticks) and helminths (e.g., nematodes, cestodes, trematodes), as well as microparasites such as protozoa, bacteria, fungi, and viruses (**Table 17**). Cases of disease and parasite infections in sharp-tailed grouse and their subsequent effects on populations are poorly documented (Peterson 2004). Most of what is known comes from studies on subspecies other than CSTG (reviewed by Tirhi 1995, Connelly et al. 1998, Peterson 2004). A review of the literature by Braun and Willers (1967) documented at least 11 species of protozoan parasites and 20 species of helminth parasites in sharp-tailed grouse. Hillman and Jackson (1973) reported consistent and heavy parasite loads in plains sharp-tailed grouse from South Dakota. Of 800 grouse examined, less than 10 were free from ectoparasites and helminths. Up to 20 species of parasites were found in a single grouse, with six to eight species usually present year-round and eight to 12 species present during the summer months. Males on leks were the most heavily parasitized group. Young collected in August and September also had heavy parasite loads. Female grouse had lower but more consistent parasite loads than males or young grouse. Parasite loads were generally lowest from December through early March. Ectoparasites were found on day-old chicks and helminths were present at two weeks of age.

Parasitic infections in sharp-tailed grouse are natural and not responsible for any substantial mortality (Edminster 1954). However, the potential for population impacts should not be dismissed (Peterson 2004). Disease outbreaks in grouse can easily go undetected (Braun et al. 1994), and there are cases where parasitic infections have been documented to impact grouse populations. For example, parasites have caused significant mortality in red grouse (*Lagopus lagopus scoticus*), a subspecies of willow ptarmigan (Hudson 1992). Naugle et al. (2004) concluded that West Nile virus significantly reduced late summer survival of some greater sage-grouse populations in the western United States and Canada. West Nile virus also has been reported to cause mortality in ruffed grouse and greater prairie-chickens (Center for Disease Control, West Nile virus avian mortality database; htpp://www.cdc.gov/ncidod/dvbid/westnile/qa/wnv_birds.htm, accessed 7 July 2006). To date, West Nile virus has not been reported in sharp-tailed grouse. This may be due to the lack of intensive monitoring of sharp-tailed grouse since West Nile virus has spread westward. Within the range of CSTG in Region 2, West Nile virus has been confirmed in several bird species from northwestern Colorado (Colorado Department of Health and Environment; http://codphe.state.co.us/dc/zoonosis/wnv/wnvhom.html, accessed 7 July 2006), including greater sage-grouse. At least one dead greater sage-grouse found in Carbon County, Wyoming also has tested positive for West Nile virus (Naugle et al. 2004).

Approximately 110 CSTG trapped in northwestern Colorado and transplanted to southwestern and north-central Colorado were tested for avian influenza, *Salmonella pullorum*, *Mycoplasma gallisepticum*, *Mycoplasma synoviae*, and *Mycoplasma meleagridis* before being released. No clinical signs of disease were apparent in any of the birds captured and all samples tested negative (Colorado Division of Wildlife, unpublished data).

Envirogram

An envirogram is a graphic representation of the proximal and distal causes/components that affect a species' chance to survive and reproduce (Andrewartha and Birch 1984). Within the envirogram model, the environment comprises everything that might influence an animal's chance to survive and reproduce. The environment consists of the "centrum" and "web". Only those things that are proximate causes of change in the animal's performance, physiology, or behavior are placed in the centrum. These are the directly acting components of the environment, such as food, cover, and predators. The centrum includes three subdivisions: resources, malentities (negative stressors in the environment), and predators. Everything else acts indirectly, through an intermediary or chain of intermediaries, to influence the components in the centrum. All the indirectly acting components are

Table 17. Reported parasites and diseases of wild sharp-tailed grouse (modified from Peterson 2004).

Group/species	State or Province (n, percent prevalence)	Reference
Mallophaga		
Amyrsidea sp.	Manitoba (218, 21)	Dick 1981
	Wisconsin	Emerson 1951
A. perdicis	South Dakota (60, 23)	Boddicker and Hugghins 1965
Goniodes sp.	Ontario	Tsuji et al. 2001
	Wisconsin	Gross 1930
G. nebraskensis	Manitoba	Emerson 1951
	Manitoba (218, 94)	Dick 1981
	Montana	Emerson 1951
	Nebraska	Emerson 1951
	North Dakota	Emerson 1951
	Ontario	Emerson 1951
	South Dakota (60, 55)	Boddicker and Hugghins 1965
Lagopoecus gibsoni	Manitoba (218, 56)	Dick 1981
L. perplexus	Ontario	Emerson 1951
	South Dakota (60, 3)	Boddicker and Hugghins 1965
	Washington	Emerson 1951
Mites		
Ornithonyssus sylviarum	Manitoba (218, 7)	Dick 1981
Unidentified	South Dakota (60, 2)	Boddicker and Hugghins 1965
Ticks		
Haemaphysalis sp.	Minnesota	Green and Shillinger 1932
H. chordeilis	Manitoba (218, 95)	Dick 1981
	South Dakota (60, 3)	Boddicker and Hugghins 1965
H. leporispalustris	Manitoba (218, 96)	Dick 1981
	Michigan	Baumgartner 1939
	South Dakota (60, 5)	Boddicker and Hugghins 1965
Hippoboscid fly		
Ornithoyia anchineuria	Manitoba (218, 16)	Dick 1981
Nematodes		
Ascaridia galli	Minnesota (53, 9)	Boughton 1937
	Wisconsin (62, 19)	Morgan and Hamerstrom 1941
Capillaria contorta	Wisconsin (126, 9)	Morgan and Hamerstrom 1941
Cheilospirura spinosa	Minnesota (53, 4)	Boughton 1937
	South Dakota (6, 17)	Boughton 1937
	Wisconsin (62, 5)	Morgan and Hamerstrom 1941
Cyrenia colini	South Dakota (6, 33)	Boughton 1937
	South Dakota (60, 62)	Boddicker and Hugghins 1965
	Wisconsin (62, 63)	Morgan and Hamerstrom 1941
Dispharynx nasuta	South Dakota (60, 5)	Boddicker and Hugghins 1965
Heterakis gallinarum	South Dakota (6, 17)	Boughton 1937
	Wisconsin (62, 31)	Morgan and Hamerstrom 1941

Table 17 (concluded).

Group/species	State or Province (n, percent prevalence)	Reference
Nematodes (continued)		
Subulura strongylina	South Dakota (6, 50)	Boughton 1937
	South Dakota (60, 52)	Boddicker and Hugghins 1965
	Wisconsin (62, 5)	Morgan and Hamerstrom 1941
Cestodes		
Choanotaenia infundibulum	Wisconsin (62, 18)	Morgan and Hamerstrom 1941
	Minnesota	Boughton 1937
Raillietina centrocerci	South Dakota (60, 62)	Boddicker and Hugghins 1965
R. variabilis	North Dakota (34, 3)	Aldous 1943
	Wisconsin (28, 4)	Gross 1930
Rhabdometra nullicollis	North Dakota (34, 9)	Aldous 1943
	South Dakota (60, 10)	Boddicker and Hugghins 1965
	Wisconsin (28, 4)	Gross 1930
	Wisconsin (62, 15)	Morgan and Hamerstrom 1941
	Minnesota	Boughton 1937
Trematodes		
Agamodistomum sp.	Minnesota	Boughton 1937
Athesmia wehri	Montana	McIntosh 1937
Brachylaima fuscatum	Alaska	Babero 1953
Echinostoma revolutum	South Dakota	Hillman and Jackson 1973
Hermatozoa		
Leucocytozoon sp.	Michigan	Baumgartner 1939
L. bonasae	Wisconsin (41, 37)	Flakas 1952
	Michigan (126, 53)	Cowan and Peterle 1957
Plasmodium pedioecetii	North Dakota (130, 41)	Shillinger 1942
	Colorado (8, 50)	Stabler et al. 1974
Trypanosoma avium	Colorado (8, 25)	Stabler et al. 1974
Haemoproteus mansoni	Unknown	White and Bennett 1979
Other protozoa		
Eimeria dispersa	Minnesota (30, 3)	Boughton 1937
E. angusta	Minnesota (39, 18)	Boughton 1937
	Wisconsin (62, 5)	Morgan and Hamerstrom 1941
Sarcocystis sp.	Alberta (76, 1)	Drouin and Mahrt 1979
Bacteria		
Francisella tularensis	Minnesota	Green and Shillinger 1932
Fungi		
Trichophyton sp.	South Dakota	Hillman and Jackson 1973

placed in the web from left to right depending on the level of their influence on the components in the centrum, with those having the most direct influence placed immediately to the left.

The envirogram developed for the CSTG is specific to Region 2 (**Figure 11a**, **Figure 11b**, **Figure 11c**, and **Figure 11d**). Some components in the web are not pertinent to other regions within the range of CSTG. For instance, mine reclamation lands are a small but important cover type used by CSTG in Region 2. This cover type is not found elsewhere within the range of CSTG. Practices applied to reclaim these lands have a pronounced influence on their value in providing food and cover for CSTG.

CONSERVATION

Conservation Status of Columbian Sharp-tailed Grouse in Region 2

Sufficient evidence exists to suggest CSTG should be considered a subspecies of high conservation concern in Region 2. Populations have disappeared across southwestern Wyoming and western Colorado, which together encompass the historical range occupied by CSTG in Region 2. The current occupied range in south-central Wyoming and northwestern Colorado represents only 3 and 15 percent of the historical distribution in Wyoming and Colorado, respectively (Bart 2000). Further loss and degradation of habitats in Region 2 threaten the stability of the remaining population. Region 2 supports one of only two metapopulations of CSTG in the United States and the third largest population anywhere throughout the subspecies' range. Some of the largest, contiguous blocks of native habitats (i.e., shrubsteppe and mountain shrub) still occupied by CSTG are in Region 2, and previously occupied habitats within Region 2 offer the greatest potential for re-establishing populations of CSTG in historic ranges. For these reasons, and because the CSTG has been petitioned twice for federal listing as threatened or endangered (Carlton 1995, Banerjee 2004), CSTG should be considered a subspecies of special concern and afforded high conservation status in Region 2.

Threats

General

All species of grouse have strongholds in natural ecosystems (Johnsgard 1973, Storch 2000). Maintaining healthy grouse populations requires large,

relatively undisturbed, natural landscapes. Whereas some grouse species can tolerate a moderate degree of habitat disturbance and can even use and benefit from artificially-created habitats, the healthiest grouse populations are associated with extensive natural landscapes exposed to natural disturbance regimes (Johnsgard 1973, Storch 2000). The CSTG is no exception. However, because the CSTG is known to use CRP fields, mine reclamation lands, and occasionally grain fields, it is considered one of the grouse with a moderate tolerance to habitat changes. Columbian sharp-tailed grouse can exist in simple or complex vegetation types as long as those cover types provide an adequate combination of food and cover. Nonetheless, it needs to be emphatically stated that CSTG in Region 2 cannot persist in artificially-created habitats alone nor can they persist on small, isolated tracts of native habitats. The fact that the subspecies has disappeared from over 90 percent of its former range is testimony enough to the importance of maintaining large expanses of native habitats in good ecological condition (**Figure 12**).

Numerous factors have been identified as threats to CSTG. These threats can be placed in one of three major categories: loss of habitat, degradation (including fragmentation) of habitat, and disturbances to populations (e.g., disease, parasites, inbreeding, hunting, other recreational activities). The two most unequivocal threats to CSTG throughout the subspecies' range are habitat loss and degradation (Hart et al. 1950, Buss and Dziedzic 1955, Marks and Marks 1987, Wood 1991, Giesen and Connelly 1993, Ritcey 1995, Tirhi 1995, McDonald and Reese 1998, Schroeder et al. 2000, Hoffman 2001, Utah Division of Wildlife Resources 2002). Much of the native habitat that remains has been altered both structurally and floristically. In some areas, these impacts have been so extensive that the few remaining unaltered habitats are often too small and widely spaced to support viable grouse populations.

Factors responsible for the loss and degradation of habitats are all human-related and include conversion of native cover types to croplands, excessive grazing by domestic livestock, herbicide treatments, fire suppression, invasion of conifers and non-native plants, urban and rural developments (including roads and utility lines), and energy development. Although the major threats have remained the same, the causes have changed over time. For example, historically, the primary cause of habitat loss was intensive agriculture; while some lands are still being converted to agricultural uses, the primary causes of habitat loss in recent years have been urban, rural, and energy development.

WEB 4	WEB 3	WEB 2	WEB 1	CENTRUM

RESOURCES

Topography/soils

Site disturbance — Noxious weeds

Intensity — Grazing

Timing — Wild ungulates — Grazing — Plant diversity

Frequency — Domestic ungulates

Distribution

Duration — Interspersion of cover types

Topography/soils

Reclamation practices — Energy

Post-reclamation use — Roads — Landscape configuration

Utility corridors — Development

Water impoundment

Habitat conversion

Habitat alteration

Herbicides — Farming practices/programs

Amount — WHIP/EQUIP

Composition — CRP

Distribution — Weather

Site disturbance — Noxious weeds

Grazing — Suppression policy — Fire

Size

Timing — Prescribed fire

Frequency

Wild ungulates — Competition

Domestic ungulates — Pesticides

Weather

Food: insects, forbs, grass, seeds, fruits, buds

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Roads/vehicles

Utility corridors

Fences — Disturbances

Development

Acoustic

Recreational activities

Topography/soils

Pasture — Ungulate grazing — Height and density of vegetation

Hay

CRP — Habitat conversion/alteration

Mine reclamation

Nesting habitat

Brood habitat — Interspersion of cover types

Escape cover

Knolls

Ridges — Topography

Gentle slopes

— Lek sites —

Figure 11a. Resource centrum of the envirogram for Columbian sharp-tailed grouse.

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WEB 4	WEB 3	WEB 2	WEB 1	CENTRUM

RESOURCES (cont.)

Nesting habitat:

- Vegetation density and height
  - Ungulate grazing
    - Topography/soils
    - Weather
    - Intensity
    - Timing
    - Frequency
    - Distribution
    - Duration
  - Farming practices/ programs
    - CRP
    - WHIP/EQUIP — Structure, Composition, Distribution
    - Timing of haying
    - Herbicides
  - Reclamation practices
    - Structure
    - Composition
    - Post-reclamation use
  - Noxious weeds
    - Site disturbance
    - Grazing
- Patch size
  - Development
  - Habitat conversion
- Topography
  - Gentle/moderate slopes
  - Broad ridges
- Distance to lek
- Distance to brood habitat

Brood habitat:

- Diversity and abundance of forbs
  - Ungulate grazing
    - Topography/soils
    - Weather
    - Intensity
    - Timing
    - Frequency
    - Distribution
    - Duration
  - Farming practices/ programs
    - CRP — Structure, Composition, Distribution
    - WHIP/EQUIP
    - Herbicides
  - Reclamation practices
    - Composition
    - Structure
    - Post-reclamation use
  - Noxious weeds
    - Grazing
    - Site disturbance
- Vegetation height and density
  - Topography/soils
  - Weather
  - Ungulate grazing
    - Intensity
    - Timing
    - Frequency
    - Distribution
    - Duration
  - Farming practices/ programs
    - CRP — Structure, Composition, Distribution
    - WHIP/EQUIP
    - Herbicides
    - Haying

CENTRUM: COLUMBIAN SHARP-TAILED GROUSE

Figure 11b. Resource centrum (continued) of the envirogram for Columbian sharp-tailed grouse.

WEB 4	WEB 3	WEB 2	WEB 1	CENTRUM

Structure ———┐
Composition ———┼— Reclamation practices ———┐
Post-reclamation use ———┘   │
                                             ├— Vegetation height
Grazing ———┐   │   and density ———┐
Site disturbance ———┴— Noxious weeds ———┘   Patch size ———┼— Brood habitat
                                             Interspersion of │   (concluded)
                                              cover types ———┤
                                             Distance to nesting ┘
                                              habitat

Topography/soils ———┐
Weather ———┤
Habitat conversion ———┐   Development ———┤
Habitat alteration ———┴   │
Habitat conversion ———┐   Farming practices/ ┤
Herbicides ———┴   programs   │
Intensity ———┐   ├— Abundance,
Timing ———┤   │   distribution, and
Frequency ———┼— Ungulate grazing ———┤   │   composition of
Duration ———┤   │   deciduous shrubs ———┐
Distribution ———┘   │   │
Intensity ———┐   │   │
Frequency ———┼— Wild fire ———┤   │   │
Suppression policy ———┘   │   ├— Winter habitat ———
Size ———┐   │   │
Intensity ———┤   │   │
Timing ———┼— Prescribed fire ———┘   │   │
Frequency ———┘   │   │
Weather ———┐   │   │
Topography ———┴— Snow depth ———┐   │   │
                                ├— Snow conditions ———┤   │
Weather ———┐   │   │   │
Topography ———┴— Surface texture ┘   │   │
                                                       │   │
Topography/soils ———┐   Height of deciduous ———┐   │
Grazing ———┴— shrubs   │
                        Distance to breeding ———┘
                         habitat

COLUMBIAN SHARP-TAILED GROUSE

Figure 11c. Resource centrum (concluded) of the envirogram for Columbian sharp-tailed grouse.

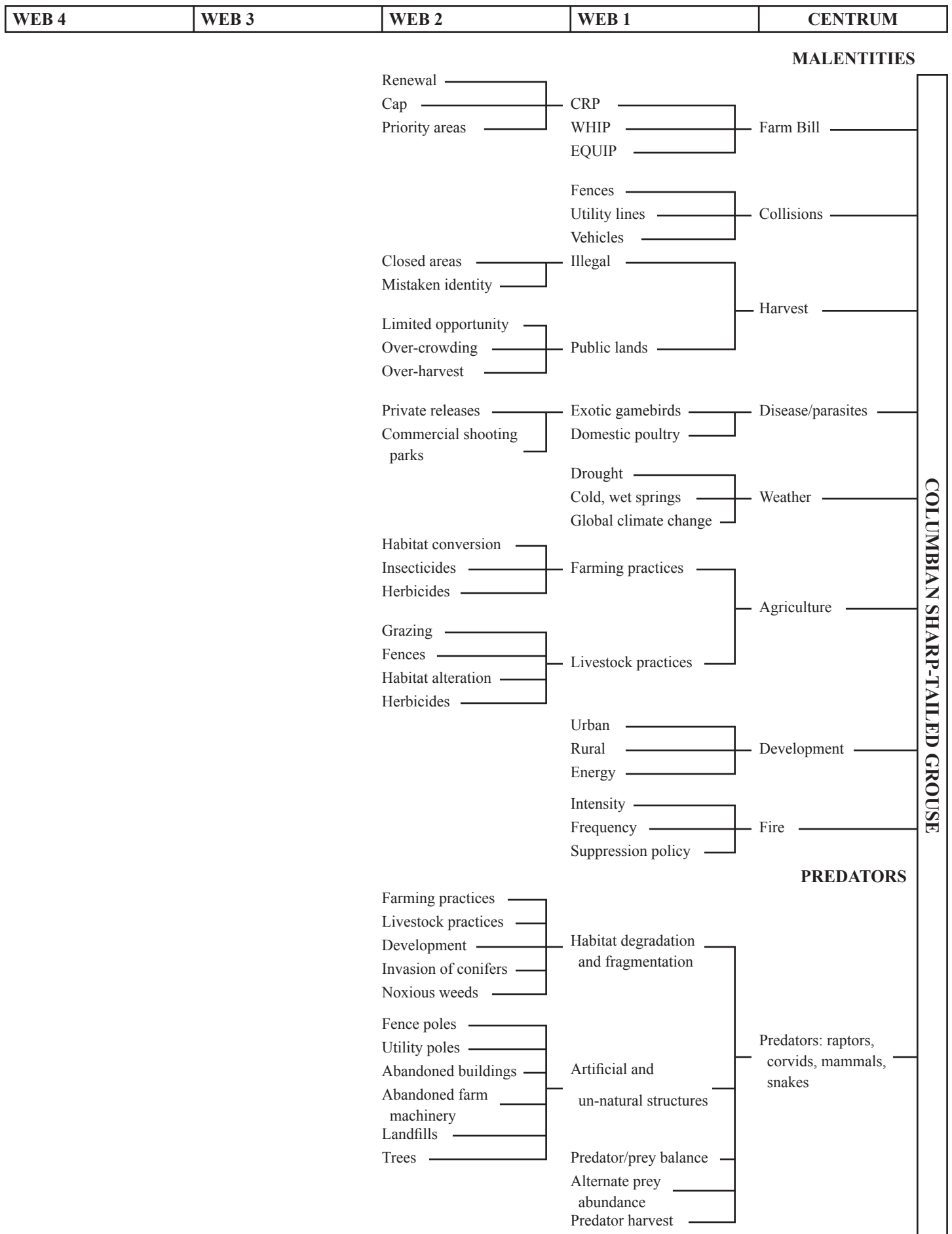| WEB 4	WEB 3	WEB 2	WEB 1	CENTRUM

MALENTITIES

Renewal ——
Cap —— CRP ——
Priority areas —— WHIP —— Farm Bill ——
EQUIP ——

Fences ——
Utility lines —— Collisions ——
Vehicles ——

Closed areas —— Illegal ——
Mistaken identity —— Harvest ——

Limited opportunity ——
Over-crowding —— Public lands ——
Over-harvest ——

Private releases —— Exotic gamebirds —— Disease/parasites ——
Commercial shooting parks —— Domestic poultry ——

Drought ——
Cold, wet springs —— Weather ——
Global climate change ——

Habitat conversion ——
Insecticides —— Farming practices ——
Herbicides ——
Agriculture ——

Grazing ——
Fences ——
Habitat alteration —— Livestock practices ——
Herbicides ——

Urban ——
Rural —— Development ——
Energy ——

Intensity ——
Frequency —— Fire ——
Suppression policy ——

PREDATORS

Farming practices ——
Livestock practices ——
Development —— Habitat degradation and fragmentation ——
Invasion of conifers ——
Noxious weeds ——

Fence poles ——
Utility poles ——
Abandoned buildings —— Artificial and un-natural structures —— Predators: raptors, corvids, mammals, snakes ——
Abandoned farm machinery ——
Landfills ——
Trees ——

Predator/prey balance ——
Alternate prey abundance ——
Predator harvest ——

COLUMBIAN SHARP-TAILED GROUSE

Figure 11d. Malentities and predator centrums of the envirogram for Columbian sharp-tailed grouse.

Figure 12. Maintaining large tracts of native shrubsteppe and mountain shrub cover types in good ecological condition is instrumental to long-term conservation of Columbian sharp-tailed grouse in USDA Forest Service Rocky Mountain Region. Photograph by Richard W. Hoffman.

Threats to CSTG are widespread across the subspecies' range (reviewed by Bart 2000); occur at all spatial scales; and transcend local, state, regional, and international boundaries. There are probably other factors happening now or that may happen in the future that will eventually become threats to CSTG, such as the growing interest by private landowners in establishing shooting preserves and releasing game farm birds for harvest by paying clients. In addition, there are newly identified threats, the consequences of which remain uncertain because the full magnitude of their impact has yet to occur. Examples within Region 2 include oil and gas development, West Nile virus, and global climate change. Many threats that have been identified are inter-related and synergistic in their impacts on CSTG populations and habitats. Even when threats are not related, their impacts tend to be cumulative. This makes it difficult to evaluate each threat individually and to separate and prioritize them. An attempt is made here to address the threats based on their existing severity and future potential to impact CSTG populations in Region 2. Clearly, certain threats have greater potential impacts than others do, but biologists and land managers must broaden their perspective and consider the cumulative impacts of threats to CSTG when formulating management strategies.

Oil and gas development

Oil and gas development was not identified as a major threat in the Northwest Colorado Columbian Sharp-tailed Grouse Conservation Plan (Hoffman 2001). At the time the plan was completed, much of the oil and gas activity in northwestern Colorado was outside or near the fringes of the range of CSTG, and exploration and development of new fields was occurring at a relatively slow pace. This is no longer the case. Oil and gas prices are at an all-time high. In addition, the current federal administration strongly supports more domestic oil and gas production and exploration to reduce the nation's reliance on foreign energy sources. This has prompted an increase in oil and gas development throughout the West (reviewed by Braun et al. 2002, Connelly et al. 2004). Oil and gas exploration and development have expanded into core areas within the range of CSTG in Region 2, including northwestern Moffat County, western Routt County, and south-central Wyoming. Approximately 75 percent of the occupied range of CSTG in Region 2 is designated as having medium to high potential oil and gas resources (**Figure 13**).

The Interior West supports much of the onshore oil and gas under federal and private ownership within
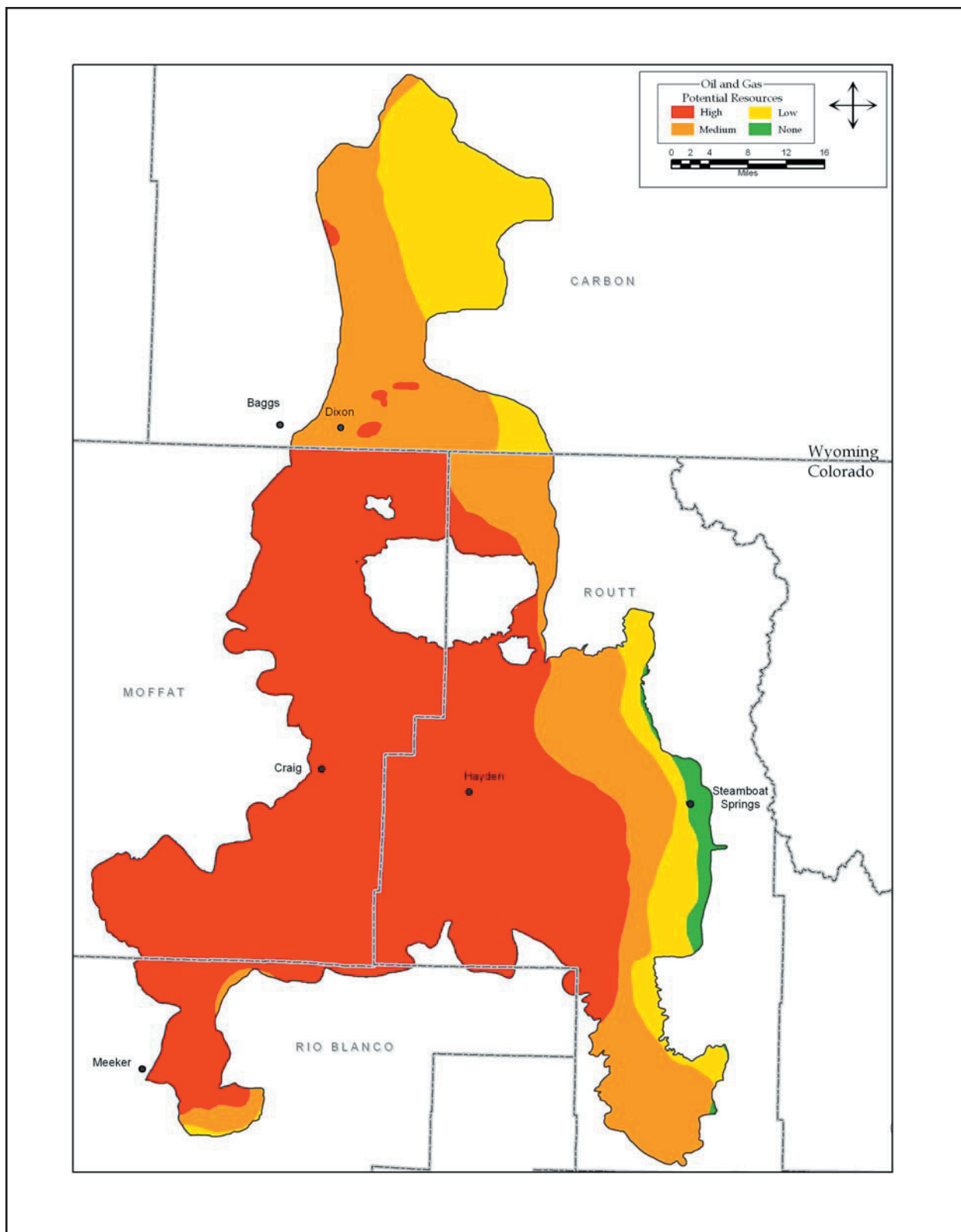
Figure 13. Potential oil and gas resources within the occupied range of Columbian sharp-tailed grouse in USDA Forest Service Rocky Mountain Region.

the contiguous 48 states. One of the major goals of the oil and gas industry is to open drilling in restricted areas, including portions of the Rocky Mountains (American Gas Foundation 2004). In recent years, a 60 percent increase has occurred in the number of permits for drilling gas wells in the Rocky Mountain West (American Gas Foundation 2005). Connelly et al. (2004) reported that from 1929 to 2004, 122,496 applications for oil and gas leases were filed with the BLM in 13 western states, of which 95.7 percent were authorized, 3.0 percent were pending, 1.2 percent were withdrawn, and less than 0.1 percent were rejected. Wyoming and Colorado accounted for 54 percent of the 122,496 applications filed with the BLM and ranked first and second, respectively, in terms of the number of applications for oil and gas leases among the eight states with existing populations of CSTG.

Connelly et al. (2004) only reported data through 2004; substantially more applications have been filed since they published their report. Their data only pertain to lands where the federal government owns the mineral rights. Lands where the mineral rights are privately owned comprise about 30 percent of the occupied range of CSTG in Region 2. This is a serious threat to CSTG because regulations governing oil and gas development on lands with private mineral rights are far less restrictive than on lands with federally owned minerals (Braun et al. 2002).

Adverse effects of oil and gas development can be divided into seven general categories:

❖ loss of habitat

❖ habitat fragmentation and isolation

❖ disturbance and displacement of wildlife

❖ physiological stress to wildlife

❖ introduction of predatory and competitive organisms

❖ direct mortality due to collisions with vehicles and utility lines

❖ secondary effects created by work force assimilation and growth of service industries.

Oil and gas developments are typically configured as point and linear distances scattered throughout broader areas. Collectively, the amount of habitat affected by oil and gas development may only encompass 5 to 10 percent of the landscape. However, avoidance and stress responses of wildlife may extend the influence from each well pad, road, pipeline, power line, and other facilities to surrounding habitats. Zones of negative influence may reach over 1 km on open ranges and affect use of habitats that otherwise appear undisturbed. The impacts of oil and gas developments can be especially problematic when they occur within limited areas such as crucial winter and reproductive habitats.

Braun et al. (2002) contended that all species dependent upon sagebrush and mountain shrub cover types are at risk from oil and gas developments. Until recently, the species of primary concern in Region 2 and throughout the West relative to oil and gas activity has been the greater sage-grouse (Braun et al. 2002, Connelly et al. 2004, Holloran and Anderson 2005). Beck (2006) summarized the current state of knowledge on the effects of oil and gas development and production activities on prairie grouse, relying on 11 papers that reported empirical evidence of impacts on greater sage-grouse and lesser prairie-chickens. Most of the available information deals with lek abandonment and changes in male lek attendance. Fewer studies have examined nest initiation, nest success, survival, or habitat selection. Beck (2006) cautioned that none of the reviewed studies was manipulative or *quasi* experiments from which strong inferences could be made about the impacts of oil and gas development. Most were observational or correlative studies. Despite their weaknesses, the studies resulted in some similar conclusions. Corroboration of results of several studies even under different conditions and locales is called metareplication (Johnson 2002) and provides some validity to the findings. For instance, lek abandonment near oil and gas activity has been reported for studies of lesser prairie-chickens in New Mexico and greater sage-grouse in Alberta, Colorado, Montana, Utah, and Wyoming. Each study was conducted under different conditions and used different methodology, but each reached similar conclusions, indicating that lek abandonment may in fact be related to oil and gas activity. The major findings on the impacts of oil and gas development as reported by Beck (2006) are summarized below.

Greater sage-grouse:
❖ In western Wyoming, fewer males recruited to leks as distance to drill rigs decreased (Kaiser 2006). No relationship was found between male recruitment and proximity of leks to main haul roads or producing wells. However, fewer males recruited to leks as distance inside an area buffered to represent

oil and gas development increased. In the same study, fewer yearling females visited leks as distance to producing wells decreased. No relationship was found between adult female visits and distance to producing wells or between adult and yearling female visits and distance to drill rigs or main haul roads.

❖ In northeastern Wyoming, fewer males were counted on leks within 1.6 km of compressor stations than on leks over 1.6 km from compressor stations (Braun et al. 2002). Also, fewer males were counted on leks within 0.4 km of coalbed methane wells than on leks over 0.4 km away. Growth rates based on counts were lower for leks within 0.4 km of power lines compared to leks over 0.4 km from power lines.

❖ In Alberta, three leks were abandoned when roads or well sites were developed within 200 m of the leks (Braun et al. 2002). The sites have since been reclaimed, but the grouse have not returned.

❖ In Colorado, high male counts were correlated with numbers of active and inactive wells within 3.2 km from leks. The best model included a year effect. A weak negative effect of active wells was detected in northwestern Colorado, but this effect disappeared when yearly variation was considered (Lukacs 2006).

❖ From 1988 to 2005, an 84 percent decline occurred in males counted on leks after coalbed methane development in the Powder River Basin of Wyoming (Naugle et al. 2006a). The largest leks were outside of coalbed methane developed areas.

❖ The average annual number of males counted per lek declined 44 percent on a coalbed methane developed area in Utah compared to a 15 percent increase on an undeveloped area (Crompton and Mitchell 2005). A new well caused abandonment of a lek that was 200 m from the pump jack. In the same study, survival of eight females (12.5 percent) captured in the coalbed methane area was less than survival of 11 females (73 percent) captured in the undeveloped area.

❖ In western Wyoming, total males counted on heavily impacted leks (>15 wells within 5 km of lek) declined 51 percent from the year prior to impact until 2004. Average annual declines were 16 percent on heavily impacted leks (excluding three centrally located leks that declined 89 percent), 19 percent on lightly impacted leks (5 to 15 wells within 5 km of lek), and 2 percent on control leks (<5 wells within 5 km of lek). These data indicate the number of males attending leks declines as the number of wells increases and that greater sage-grouse are eventually excluded from breeding within developed gas fields (Holloran 2005, Holloran and Anderson 2005). A negative change in annual lek counts was noted for leks within 5 km of drilling rigs, 3 km from producing wells, and 3 km of main haul roads. Well densities exceeding one well per 2.8 km^2 appeared to affect male attendance at leks negatively.

❖ In northwestern Wyoming, Lyon and Anderson (2003) reported that females from disturbed leks (<3 km from gas development) moved significantly farther to nest sites and had a lower nest initiation rate than females from undisturbed leks did (>3 km from gas development). No differences were detected in nesting success. The longer movements and lower nesting rate of females from disturbed leks were attributed to increased vehicle activity near disturbed leks.

❖ In Wyoming, annual survival for nesting adult females was 73 percent prior to gas development and 53 percent post-development (Holloran 2005).

❖ Grouse avoided coalbed methane development in suitable habitat during winter in the Powder River Basin of Wyoming (Naugle et al. 2006b).

❖ Avian predation of nests in western Wyoming increased from 13 to 40 percent as oil and gas development increased (Holloran 2005).

❖ Hatch dates averaged five days later for females that nested within an oil and gas buffered region in Wyoming compared to females that nested outside the buffer (Kaiser 2006).

Lesser prairie-chicken:

❖ Eighteen (45 percent) of 40 abandoned leks and only one (3 percent) of 33 active leks in southeastern New Mexico were less than 800 m from a power line (Hunt 2004).

❖ Road density within a 1.6 km buffer was higher surrounding abandoned (3.3 km per km^2) than active (2.4 km per km^2) leks in southeastern New Mexico (Hunt 2004).

❖ Abandoned leks in southeastern New Mexico had more active wells and more total wells within 1.6 km than active leks. The mean number of wells within 1.6 km was one for active leks and eight for abandoned leks during their last year of activity. Noise levels were approximately 4 decibels higher at abandoned leks that at active leks (Hunt 2004).

❖ Nest locations in southwestern Kansas were influenced by transmission lines, well heads, buildings, improved roads, and center-pivot irrigated fields. The nearest 10 percent of nests to each feature were farther from the feature than would be expected at random (Pitman et al. 2005).

The impacts of oil and natural gas are long-term. A typical oil and gas well has a production life of 20 years. Developed fields may expand in size as they mature, but more frequently, infill development occurs within the field. As established wells become less productive, more wells are drilled to extract the remaining resource. Thus, the initial disturbance associated with drilling may resume as the field matures. In this situation, the impacts associated with the resumption of drilling activities compound the impacts to wildlife from existing wells. Following drilling, there are more wells within the same area, which in itself may have negative consequences to wildlife.

Loss of Conservation Reserve Program land

Nearly 90 percent of the breeding, nesting, and brood-rearing habitats of CSTG in Region 2 are on private lands. Without private landowner cooperation, opportunities for protection and management of CSTG in Region 2 are limited. Changes in the way private lands are managed can have significant positive or negative impacts on CSTG populations. A prime example is the Conservation Reserve Program. This private lands program has resulted in positive population responses by sharp-tailed grouse and other prairie grouse in many portions of their range (Rodgers and Hoffman 2005). Within the occupied range of CSTG in Region 2, all CRP lands are in Colorado. These lands, which total nearly 23,000 ha, were formerly wheat fields that CSTG seldom used except for a short period in late fall and early winter following harvest (Hoffman 2001). Today, these lands support about 21 percent of the known leks and, depending on their structure and composition (Hoffman 2001, Boisvert 2002, Rodgers and Hoffman 2005), provide critical nesting and brood-rearing habitat. The conservation plan for CSTG in northwestern Colorado clearly indicates a population decline can be expected if this program is discontinued (Hoffman 2001).

No national legislation will affect CSTG more than reauthorization of the Farm Bill in 2007. Congress is considering focusing more CRP lands on wetlands protection and production of vegetation to produce ethanol; thus as contracts expire in the West, CRP acreage could be shifted to other areas of the country. Of the 23,000 ha of CRP in northwestern Colorado (Moffat and Routt counties) approximately 16,500 ha (72 percent) are due to expire in September 2007. The Farm Service Agency (FSA) recently announced it will offer certain CRP participants the opportunity to re-enroll in new CRP contracts or to extend current contracts. The FSA ranked all expiring contracts according to the Environmental Benefits Index (EBI) factors at the time of the original offer and whether the property fell within a National Priority Area. None of the National Priority Areas was in Colorado or Wyoming; consequently, few of the participants with expiring contracts will be given the opportunity to re-enroll. In Routt County, only about 7 ha of the 5,919 ha due to expire in 2007 are eligible for re-enrollment. Owners of the remaining 5,912 ha will be given the opportunity to extend their contracts for a period of two to five years depending on their EBI score. Most of these lands will only be allowed a 3-year extension. The situation is similar in Moffat County, with few contracts eligible for re-enrollment and the vast majority only eligible for a 3-year extension. This presents a tenuous situation for CSTG in Colorado. Within the next five years, most of the CRP fields that provide breeding, nesting, and brood-rearing areas for CSTG may no longer be protected. Although the new Farm Bill could change this situation, presently, the prospect for maintaining these critical habitats in the long term is in serious jeopardy.

Even if the new Farm Bill allows participants to re-enroll, it is probable that some landowners will not do so because their land has greater value for other

uses, mainly development. This is particularly the case for much of the CRP land in Routt County. These lands have high development potential due to their proximity to Steamboat Springs. The fate of other CRP lands due to expire is unknown. Some fields may be converted to crops, but it is more likely that fields with fences and water sources will be grazed. Others may be mowed for hay or plowed and replanted with more palatable grasses, and then used for hay, or grazing, or both.

Loss of CRP also may negatively impact native cover types. Due to the absence of fences, native cover types immediately adjacent to CRP are seldom grazed. Consequently, they are often in excellent ecological condition. The combination of CRP and quality native cover creates ideal habitat for CSTG. However, if the contract expires and the former CRP land is grazed, it is likely the adjacent native cover also will be grazed and even possibly treated with herbicides to increase forage production for livestock. Any of these activities will be detrimental to CSTG.

Grazing

Livestock grazing is the dominant land use on public and private lands within the occupied range of CSTG in Region 2. Livestock grazing affects soils, vegetation, and animal communities (Jones 2000). Livestock consume and alter vegetation, redistribute nutrients and plant seeds, trample soils and native plants, and disrupt microbiotic crusts (Miller et al. 1994, West 1996, Belhap and Lange 2001). These changes can lead to loss of vegetative cover, loss of herbaceous and woody species, reduced water infiltration rates, increased soil erosion, and invasion of exotic plants (Mack 1981, Tisdale and Hironaka 1981, Saab et al. 1995, Rotenberry 1998). This affects grouse populations using these plant communities in three main ways. First, high levels of grazing can reduce or eliminate key food plants for grouse. Many of these same plants also attract insects, so secondly, grazing can reduce the abundance of insects important to the growth and development of chicks. Third, grazing can lead to increased predation rates of adult and young grouse by reducing cover needed for concealment from predators. The direct effects of grazing are further compounded by actions designed to control and protect livestock, and to promote forage production for livestock. Examples of such actions include building of fences and roads, mechanical and chemical treatments of shrub-dominated communities to enhance grass production, and conversion of native plant communities to hayfields (often involving re-seeding with non-native grasses). Each of these actions can have serious implications to

CSTG populations and are addressed separately from the issue of grazing.

Grazing often selectively removes highly palatable grasses and broad-leafed forbs. This alters the competitive relationship among the different species within the plant community and may tip the balance in favor of the unpalatable species. For example, heavy grazing of the herbaceous understory within sagebrush communities reduces competition and allows sagebrush plants to spread, creating dense stands with a sparse understory of annuals and unpalatable perennials (Tisdale and Hironaka 1981). These stands may be used by CSTG as escape cover, but they are usually unsuitable for nesting and brood-rearing.

The effects of livestock grazing on native shrubland habitats are complex and depend upon intensity, season, frequency, and duration of grazing, and the distribution of grazing animals across the landscape. One of the principle concerns is that livestock grazing is believed to represent an alien ecological force on shrublands of the western United States. Unlike the grasslands of the Great Plains, western shrublands had a long history where, prior to the introduction of domestic livestock, large-hoofed grazers (particularly American bison [*Bison bison*]) were rare (Mack and Thompson 1982). Even where grazing by bison was intense, it was localized and highly variable in space and time. Current grazing management plans that attempt to use rest-rotation or other forms of variable grazing to emulate natural grazing regimes are inadequate because plant communities are not given sufficient rest, and recycling of resources is dissimilar (Bock et al. 1993, Freilich et al. 2003).

The detrimental effects of intensive grazing on CSTG are frequently alluded to in the literature. Bart (2000) concluded that grazing has caused the extirpation of CSTG on approximately 75 percent of the historic range and attributed nearly 100 percent of the losses on public lands to grazing. Hart et al. (1950) identified heavy grazing as the most important factor limiting CSTG populations on non-cultivated lands in Utah. In eastern Washington, Ziegler (1979) mentioned two negative components associated with grazing: removal of nesting and brood-rearing cover, and destruction of deciduous trees and shrubs essential for winter habitat. The latter problem was not only the result of browsing, but also trampling and rubbing. A study of summer habitat use by CSTG in western Idaho indicated that CSTG selected areas least modified by livestock grazing (Marks and Marks 1987). In southeastern Idaho, Parker (1970) noted that sheep and cattle use of chokecherry

stands completely destroyed the understory vegetation and rendered the stands useless as escape and loafing cover for CSTG. Klott and Lindzey (1990) reported that of the three plant species (oniongrass, sulphur buckwheat, and snowberry) positively associated with CSTG brood sites in south-central Wyoming, two (oniongrass and snowberry) decrease with grazing. Boisvert (2002) and Collins (2004) both cautiously implied that grazing and its subsequent effect on cover needed for nesting and brood-rearing may have been a factor contributing to the lower productivity of CSTG in grazed shrubsteppe compared to ungrazed mine reclamation lands in northwestern Colorado. Hoffman (2001) considered the absence of grazing a major reason why CSTG were attracted to CRP and mine reclamation lands in northwestern Colorado. Compared to grazed shrubsteppe, CRP and mine reclamation lands supported a higher density of leks and a greater number of males per lek (Hoffman 2001). In north-central Nebraska, Flanders-Wanner et al. (2004) partially attributed higher productivity of plains sharp-tailed grouse on Valentine National Wildlife Refuge than on the McKelvie National Forest to lower grazing pressure on the refuge.

Baines (1996) conducted one of the few studies specifically designed to measure the impacts of grazing on a grouse population. Data on black grouse (*Tetrao textrx*) densities and breeding success, insect abundance, and vegetation characteristics were collected within five blocks of moorland that differed in grazing intensity. Moors with the highest intensities of grazing had on average 36 percent less vertical vegetation cover, 32 percent shorter vegetation, and supported 41 percent fewer invertebrates than measured on lightly grazed moors. The highest densities of male and female black grouse were on lightly grazed moors. Twenty percent fewer females with broods were located on heavily grazed moors, and females on heavily grazed moors reared an average of 17 percent fewer chicks than those on lightly grazed moors did. Insufficient numbers of grouse were raised on the heavily grazed moors to maintain the populations even at the lower density, suggesting that recruitment of birds from nearby moors of better quality habitat maintained populations on the heavily grazed areas.

Grazing by wild ungulates also may negatively affect CSTG habitats. Elk herds have grown dramatically due to greater protection and enforcement of game laws and lack of natural predators. Hunting has been mostly ineffective as a means of population control. The problem is not conservative regulations but the inability to achieve desired harvest levels on private lands. Elk use of sagebrush, mountain shrub, CRP, and mine reclamation lands has increased during all seasons of the year, especially where they are not hunted or only lightly hunted.

Agriculture

Cultivation has yielded some benefit to CSTG by providing additional sources of food. However, this benefit has not nearly compensated for loss and fragmentation of native habitats caused by agriculture (Hart et al. 1950). Bart (2000) reported that CSTG have been extirpated from approximately 20 percent of their historic range due to habitat loss and fragmentation caused by intensive agriculture and its associated activities. The amount of habitat lost to agriculture varies by state. In some states, habitat conversion for agriculture, more so than grazing, is the primary reason for the disappearance and decline of CSTG (McDonald and Reese 1998, Bart 2000, Schroeder et al. 2000). In eastern Washington, habitat conversion to croplands, pasture, and hay fields resulted in a decrease in native grassland and sagebrush cover types from 25 to 1 percent and 44 to 16 percent of the landscape, respectively (McDonald and Reese 1998). Mean patch size decreased from 3,765 to 299 ha for grasslands and 13,420 to 3,418 ha for sagebrush. The consequence of these changes has been a 92 percent decline in the CSTG population in Washington (Schroeder et al. 2000). The remaining population numbers less than 1,000 grouse scattered across eight small, isolated areas (Schroeder et al. 2000). Extensive conversion of shrubsteppe to croplands and grazing was identified as the major cause for extirpation of CSTG in Oregon (Bart 2000). Hart et al. (1950) reported that CSTG have been more adversely affected by the advent of cultivation in Utah than possibly any other native game bird.

Habitat losses due to agriculture in Region 2 have not occurred at the magnitude that has taken place elsewhere within the subspecies' range (Hoffman 2001). Topography, soils, and a short growing season limit the amount of land suitable for agriculture in northwestern Colorado and south-central Wyoming. These constraints are one of the main reasons why CSTG still inhabit this area.

Loss of habitat to agriculture may be partially responsible for the disappearance of CSTG from areas outside the occupied range in Region 2. Historically, CSTG occurred throughout southwestern Colorado (Rogers 1969, Giesen and Braun 1993). The last documented sighting of CSTG in southwestern Colorado was in 1985 (Giesen 1985). Giesen and

Braun (1993) hypothesized that loss of nesting and winter habitat was responsible for the disappearance of CSTG from the majority of its historic range in western Colorado. They suggested that the mid-elevation mountain shrub habitats occupied by CSTG were the same areas favored by early settlers for initial colonization and exploitation. Oyler-McCance et al. (2001) estimated that 20 percent (range = 11 to 50%) of the sagebrush-dominated cover types in southwestern Colorado disappeared between 1958 and 1993. Because much of what was once sagebrush was already gone before the oldest photographs in their study were taken, Oyler-McCance et al. (2001) emphasized that their findings represented only a small fraction of the sagebrush that has been lost in southwestern Colorado. Citing other sources (Rogers 1964, Braun 1995), Oyler-McCance et al. (2001) indicated most of the loss was related to conversion of native cover types to farmland or housing developments. This alone was not the only reason CSTG disappeared from southwestern Colorado. As habitats were lost to cultivation and development, the remaining habitats were being intensively grazed and vast expanses were being treated with herbicides to improve forage conditions (i.e., grass production) for livestock. The combined effects of these activities are what most likely caused the extirpation of CSTG in southwestern Colorado.

Urban and rural development

Human population data reported by Connelly et al. (2004) within the current and historic range of the greater sage-grouse indicated that in 1900 about 51 percent of 325 counties had less than one person per square kilometer and 4 percent had densities greater than 10 persons per square kilometer; the corresponding figures in 2000 were 31 and 22 percent. The area examined in this report includes the entire range of CSTG in the western United States. Clearly, human populations have increased within the range of CSTG. This has placed growing pressure on the landscape to provide resources to sustain and enhance human populations. Urban and rural developments by themselves remove, degrade, and fragment habitats. Highly urbanized areas present inhospitable environments to CSTG. Roads, railways, power lines, communication corridors, fences, water developments, landfills, and other facilities and activities associated with urbanization together greatly influence CSTG and their habitats.

The ecological impacts of roads only recently have been recognized and quantified (Forman and Alexander 1998). The effects of roads on wildlife include:

❖ increased mortality from collisions with vehicles

❖ modification of behavior due to habitat or noise disturbance

❖ alteration of the physical environment

❖ alteration of the chemical environment

❖ spread of exotic species

❖ increased habitat alteration and use by humans of adjacent areas (Trombulak and Frissell 2000).

The degree of impact from roads depends upon the type of road, density of roads, and proximity to key habitat use areas.

No Interstate Highways, one U.S. Highway, and seven State Highways occur within the occupied range of CSTG in Region 2. The majority of travel routes are paved or gravel county, USFS, and BLM roads. In northwestern Colorado, few (<5 percent) active CSTG leks are within 1 km of any state or federal highway, whereas nearly 70 percent occur within 1 km of a county road (Hoffman 2001, Lassige 2002). The average distance to a federal, state, or county road is 14.6, 12.1, and 1.1 km, respectively (Hoffman 2001). Approximately 6,500 km of federal (150 km), state (400 km), and county roads (5,950 km) traverse the range of CSTG in Region 2. Concerns about roads and their impact on CSTG primarily relate to construction of new roads and improvement of existing roads (Hoffman 2001). New and improved roads generally result in increased human activities. Construction of new roads has caused abandonment of leks by lesser prairie-chickens (Crawford and Bolen 1976) and greater sage-grouse (Braun 1985, Remington and Braun 1991). Collisions with vehicles accounted for 4 percent of the known mortalities of lesser prairie-chickens in Oklahoma (Patten et al. 2005). Construction of Interstate 80 in southern Wyoming was found to significantly affect the distribution of active greater sage-grouse leks within 4 km of the interstate (Connelly et al. 2004). Hoffman (2001) suggested that there may be some threshold density of roads above which CSTG avoid or reduce their use of adjacent suitable habitats.

Power lines serve as perches and nest sites for raptors and corvids (Knight and Kawashima 1993, Steenhof et al. 1993, Avian Power Line Interaction

Committee 1996). This may increase predation rates on grouse and their nests or deter use of the immediate area. Mortality rates also may increase due to collisions with power lines (Avian Power Line Interaction Committee 1994, Bevanger 1995, Patten et al. 2005). Despite these potential impacts, rigorous data on the effects of power lines on CSTG are lacking (Hoffman 2001). Lee (1936) cites a statement by an early pioneer of the Cache Valley in northern Utah who claimed that when the telegraph line was constructed through the valley, scores of sharp-tailed grouse were killed by flying into the wires. Bevanger (1995) estimated the total annual losses of capercaillie (*Tetrao urogallus*), black grouse, and willow ptarmigan to collisions with high tension power lines in Norway as 20,000, 26,000, and 50,000, respectively. Hoffman (2001) refers to unpublished data from Montana and California indicating that greater sage-grouse abandoned lek sites following construction of new power lines. Although Hoffman (2001) reported finding two active CSTG leks under utility lines, 86 percent of the active leks (*n* = 111) found by Hoffman (2001) were located over 500 m from any utility line.

Two coal-generated power plants occur in northwestern Colorado within the occupied range of CSTG in Region 2. Consequently, large transmission lines are a prominent feature of the landscape in this area. While raptors and corvids use these lines as perches and occasionally as nest sites, they probably are not a major risk for collisions compared to the smaller utility lines because the wires are thicker and suspended higher in the air. Of the two leks found by Hoffman (2001) under power lines, both were under large transmission lines. Despite the proximity of some leks to large transmission lines, evidence from studies of radio-marked sharp-tailed grouse suggest that they seldom use otherwise suitable habitats under or immediately adjacent to these lines for nesting or brood-rearing (Boisvert 2002, Collins 2004). Avoidance of overhead structures probably represents an innate predator-avoidance behavior.

Fences are another risk for collisions and can serve as perches for raptors depending on type of wire and posts used to construct the fence. Because of the greater surface area on top, wooden posts offer better perching sites than metal posts. Woven wire may be a greater threat than stranded wire. Both types of wire can be a problem when vegetation is allowed to grow next to the fence and thus obscure the wire. Patten et al. (2005) documented that 13 percent of the known causes of mortality of lesser prairie-chickens in New Mexico (*n* = 98 carcasses) and 32 percent of the documented mortalities in Oklahoma (*n* = 100

carcasses) were the result of collisions with fences. In the Scottish Highlands, Baines and Andrew (2003) recorded 437 collisions with deer fences involving 13 different species of birds. Red grouse, black grouse, and capercaillie formed 91 percent of all collisions. Collision rates were 1.6, 1.3, and 0.9 collisions per kilometer of fence per year for red grouse, black grouse, and capercaillie, respectively.

Many people want the amenities provided by urban areas, while enjoying the solitude, open spaces, and greater freedoms (i.e., less restrictive or no covenants) of rural living. Consequently, rural developments (i.e., ranchettes) tend to increase near urban areas. Although rural developments may continue to provide some habitats for CSTG in contrast to total urban conversion, dwellings, roads, fences, utility lines, pets, and increased human activities that are part of any development generally render the habitat of marginal value to CSTG. Studies of other prairie grouse suggest they exhibit a behavioral aversion to structures (Pitman et al. 2005). The potential consequence of such behavior is that a single home placed in CSTG habitat may effectively reduce habitat availability to a much greater distance than might superficially appear.

Most people living in rural areas own livestock, particularly horses. Thus, rural areas are often intensively fenced, and livestock are typically confined to small areas. This exerts tremendous grazing pressure on the land to the point where any native habitat becomes highly degraded and useless to CSTG. Within the occupied range of CSTG in Region 2, and especially in Routt County in northwestern Colorado, the effects of rural sprawl may actually be greater than those of urban sprawl. Sale and subsequent subdividing of ranches is an ongoing major threat to CSTG in northwestern Colorado.

Urban and rural areas and their associated landfills attract and facilitate movements and range expansion of generalist predators. Corvids, skunks, raccoons, and red fox thrive in urban and rural environments. This contributes to the spread of these predators into wildland areas occupied by CSTG, where in the absence of anthropogenic features, these predators would occur at low densities or not at all. Roads, railroads, irrigation channels, and utility right-of-ways serve as travel routes for predators, and allow them to expand their range into previously unused regions. Urban and rural areas also increase the likelihood that non-native predators (e.g., feral cats and dogs) will be introduced into CSTG habitats. In addition, rural areas may increase the probability of disease transmission because CSTG

using or passing through rural landscapes are more likely to come in contact with domestic fowl.

Pesticides

Pesticides used to control insects (insecticides) and those used to kill certain species of plants (herbicides) may have both direct and indirect impacts on CSTG. Use of herbicides has had a greater impact on CSTG in Region 2 than use of insecticides has. The Columbian sharp-tailed grouse conservation plan for northwestern Colorado did not identify insecticides as a pertinent issue (Hoffman 2001). Farmers involved in the preparation of the plan said they seldom used insecticides on their crops. The primary crop in northwestern Colorado, other than hay, is wheat. Farmers indicated that growing conditions for wheat in northwestern Colorado are marginal and profits are low. Therefore, spraying fields for insects is not economically effective. They claimed the cost per acre to spray equaled or exceeded profits they would make from the sale of the wheat crop.

Insecticides are primarily used to control insects causing damage to cultivated crops on private lands. Occasionally insecticides are used on non-cultivated lands, including native cover types, as well as cultivated crops to control outbreaks of grasshoppers and Mormon crickets. Spraying can occur on public and private lands. McEwen and Brown (1966) studied the effects of dieldrin and malathion, two insecticides used for grasshopper control, on wild sharp-tailed grouse in Montana. Sixty-three percent of 19 birds treated with dieldrin and 32 percent of 19 birds treated with malathion died within 72 hours. Lethal doses of malathion ranged from 200 to 240 mg/kg of body weight while those of dieldrin ranged from 5.0 to 32.2 mg/kg. Increased vulnerability to predators and termination of breeding were attributed to sublethal doses. Ritcey (1995) reported an instance where CSTG chicks were found dead in an area that had been sprayed for grasshoppers in British Columbia. No mention was made of the type of insecticide used or the number of birds found dead. Blus et al. (1989) document that sage-grouse in Idaho died or were severely intoxicated after feeding in alfalfa fields sprayed with the organophosphorus insecticides dimethoate and methamidophus. Intoxicated grouse could not walk or fly, were emaciated, and had diarrhea, and they likely would have died or succumbed to predation. Sharp-tailed grouse occur sympatrically with sage-grouse in the area where the dieoff was documented. However, Blus et al. (1989) did not find any dead sharp-tailed grouse or mention their presence.

The arrival of West Nile virus in CSTG range presents an additional potential problem with insecticides. Widespread use of insecticides to control mosquitoes could have detrimental effects on CSTG depending on type of insecticide used, timing of spraying, and site-specific factors such as the proximity of spraying to brood-rearing areas. Use of larvicides and adulticides with low toxicities to vertebrates, which are administered in low concentrations, can mitigate risks (Rose 2004). The organophosphate malathion has been used to kill adult mosquitoes in and around urban areas for decades. Malathion at high dosages can kill sharp-tailed grouse (McEwen and Brown 1966). However, when used to kill mosquitoes, it is administered at low (219.8 ml/ha) rates and is judged to be relatively safe for vertebrates (Rose 2004). Since sharp-tailed grouse chicks rely on insects for food during the first two to three weeks of life, regardless of the toxicity, spraying of any insecticide in brood-rearing areas must be considered detrimental.

Spraying herbicides to eliminate or reduce the shrub component and increase grass production is a form of habitat conversion. The impacts of herbicides to CSTG depend on the size of the area treated and percent vegetation kill. The larger the area treated and the greater the kill, the more detrimental it will be to the grouse. The impacts are twofold and include modification of components of the habitat required for cover and modification of components required for food. Although the woody stems of the shrubs remain after treatment, their failure to produce leaves greatly reduces their value as cover. More importantly, essential foods, such as serviceberry, chokecherry, hawthorn, and various forbs, which are usually not the target species of the herbicide treatment, are killed. Insect populations also decline after treatment due to the decline in shrub and forb abundance and diversity. Treated areas are often grazed shortly after the herbicide is applied. This further reduces the cover value of the treated area and hinders recovery of the non-targeted shrubs and forbs (Giesen and Connelly 1993).

Reseeding of ranges with forage plants is often conducted following treatment with herbicides to kill shrubs. Kessler and Bosch (1982) reported that 67 percent of reseeding operations in CSTG habitats treated with herbicides involved planting of introduced grasses. The species most commonly planted was crested wheatgrass. In Region 2, the species frequently used was smooth brome because the northern growth form is better adapted to cooler, moister conditions at higher

elevations than crested wheatgrass is (Monsen 2005). Smooth brome is a strongly rhizomatous perennial, and once established, it is extremely competitive, forming dense stands to the exclusion of other plant species. Monsen (2005) strongly cautioned that smooth brome is not compatible with native plants and should not be planted where retention of native plant communities is desired. Monocultures of smooth brome offer little in the way of cover or food for CSTG (Rodgers and Hoffman 2005).

Klott (1987) reported the abandonment of two active CSTG leks in south-central Wyoming after the surrounding area was sprayed with herbicide to remove sagebrush. He also found no use of the treated areas by sage-grouse broods. Klott (1987) concluded that the treatments were detrimental to both sage-grouse and CSTG because of the size of the areas treated and the resultant change in the composition of the vegetation. Sagebrush was completely removed and serviceberry, snowberry, and bitterbrush were severely reduced. Treated areas exceeded 160 ha in size and were primarily in the mountain shrub and sagebrush-snowberry cover types. The limited nature of these cover types and their importance to CSTG led Klott (1987) to conclude the treatments were probably more harmful to sharp-tailed grouse than sage-grouse inhabiting this area.

Fire

Fires are natural events and not universally disruptive, even though considerable vegetation disturbance may occur. The impacts of fire on CSTG habitats vary and are influenced by vegetation type and timing, intensity, frequency, and size of burns (Giesen and Connelly 1993). Additionally, the effects of fire are regional and site-specific. Fires that burn large contiguous patches of habitat may be detrimental to CSTG while fires that create a mosaic of burned and unburned areas can be beneficial. Fires in the sagebrush type have the potential to be more detrimental to CSTG than fires in the mountain shrub type because sagebrush is slow to recover following fire (reviewed by Connelly et al. 2004, Gunnison Sage-grouse Rangewide Steering Committee 2005, Monsen 2005). Several species of deciduous shrubs and trees common in mountain shrub habitats, such as serviceberry, chokecherry, Gambel's oak (*Quercus gambelii*), and quaking aspen, resprout following fire (Blaisdell et al. 1982, Kufeld 1983, Monsen 2005). In contrast, sagebrush may be eliminated or severely depleted following intense and frequent fires, and it may require decades to become re-established (Bunting et al. 1987, Miller and Eddleman 2000).

Too little as well as too much fire can negatively affect CSTG habitats. In the absence of fires, fuel loads may increase so that when a fire does occur, it may burn more intensively and over a larger area. Within mountain shrub communities, fire suppression can result in expansion and dominance of oakbrush to the detriment of species more desirable to CSTG, such as serviceberry and chokecherry. Within sagebrush and grassland communities, fire suppression can promote the invasion of two-needle pinyon (*Pinus edulis*) and juniper stands (reviewed by Connelly et al. 2004). Pinyon-juniper stands are generally considered marginal or unsuitable habitats for CSTG because they provide perches and better approach cover for raptors, and support fewer forbs and grasses than the sagebrush communities they replace. Fire suppression within sagebrush communities also can contribute to dense, late-seral, monotypic stands of sagebrush that provide little habitat for CSTG and have been postulated to be more vulnerable to widespread, intense fires (Young et al. 1979).

Historically, fire was the major disturbance factor in sagebrush and mountain shrub biomes. Mean fire return intervals have been reported as low as 10 to 20 years to as high as 150 years, depending on the site and condition and composition of the vegetation (reviewed by Connelly et al. 2004). These authors cautioned that there is currently no clear picture of the complex fire regimes that characterize the sagebrush type. Researchers disagree over the frequency and scale of fires in the sagebrush type prior to settlement, but they uniformly agree that natural fire frequencies have been greatly altered over the past 150 years due to introduction of livestock and invasion of noxious weeds (reviewed by Connelly et al. 2004). In some cases, the frequency of fire has decreased. Several studies have reported a decline in fires starting in the late 1800's. This coincides with the introduction of livestock and subsequent reduction in fine fuels needed to carry fires (Miller and Rose 1999, Miller and Tausch 2001). In other cases, the introduction and expansion of noxious weeds have contributed to an increase in fires (West 2000). Monsen (2005) suggested that natural recovery from fires is unlikely in shrub communities that have been significantly altered by grazing, planting of non-native grasses, and invasion of noxious weeds. In such areas, fires may further promote growth of noxious weeds to the detriment of native shrubs, grasses, and forbs.

Fire suppression is probably of greater concern within the range of CSTG in Region 2 than occurrence of fires that burn thousands of hectares. Lack of

deciduous shrub communities is not an issue in northwestern Colorado and south-central Wyoming (Oedekoven 1985, Hoffman 2001), but the health of these communities is of concern (Hoffman 2001). Extensive stands of dense, over-mature mountain shrub communities dominated by oakbrush are common due to lack of fire. These stands have limited value as CSTG habitat except where they border more open habitat types. Few leks occur within the mountain shrub type (Hoffman 2001). Areas selected by CSTG within the mountain shrub type during winter tend to be in more open stands dominated by serviceberry (Boisvert 2002). Grouse rarely use stands dominated by oakbrush, except as loafing and escape cover. Both Rogers (1969) and Oedekoven (1985) suggested that burning in areas of dense brush may be beneficial to CSTG in Colorado and Wyoming, respectively.

Cheatgrass (*Bromus tectorum*) invasion is a serious threat to sagebrush ecosystems in the Great Basin (reviewed by Connelly et al. 2004). Cheatgrass provides a continuous fuel source for fires. Since sagebrush is intolerant to fires, it eventually disappears from areas with extensive stands of cheatgrass as fires perpetuate the highly competitive cheatgrass. As cheatgrass increases, it becomes increasingly difficult for native grasses and forbs to persist. In some areas, former sagebrush communities have been replaced almost entirely by stands of cheatgrass. Although cheatgrass is present within the occupied range of CSTG in Region 2, it does not represent the same threat as in the Great Basin. The wetter and cooler weather in northwestern Colorado and south-central Wyoming are deterrents to establishment and spread of cheatgrass. Fires occur less frequently and tend to burn over smaller areas. However, if predictions about global climate change are correct (Bachelet et al. 2001), increasing temperatures could allow for greater spread of cheatgrass and an increase in the frequency of fire in sagebrush communities in Region 2.

Recreation

While some uses of public lands have declined, other uses have markedly increased. One such use is recreation. Today, recreational activities in the form of hiking, backpacking, camping, off-road vehicles (including snowmobiles), fishing, hunting, back-country skiing, mountain biking, horseback riding, rock climbing, nature viewing, and photography are major uses of habitats occupied by CSTG on public lands.

Hoffman (2001) suggested the cumulative impacts of increased human recreational activities may have a negative effect on CSTG, but noted no experimental research has been conducted on this subject, and evidence to support this possibility is limited to observational accounts. If recreation does impact CSTG, it may occur in four ways: (1) exploitation, (2) disturbance, (3) habitat modification, and (4) pollution (Knight and Cole 1995). Of these, disturbance is probably of greatest concern. Baydack and Hein (1987) found that during spring, male sharp-tailed grouse were temporarily displaced from leks subject to disturbance, but they continued to attempt to regain their position on the lek and returned once the disturbance factor was removed. Females avoided disturbed leks at all times and made no effort to return until the disturbance was removed. Baydack and Hein (1987) concluded that leks subject to continual disturbance may become reproductively inactive due to the absence of females. Profera (1985) conducted an experiment evaluating the distance at which greater sage-grouse on leks responded to various disturbances. The findings were inconclusive but suggested that females flushed at larger approach distances than males did and that male response was related to the number of females present (i.e., the more females that were present, the more reluctant the males were to leave).

Viewing of dancing sharp-tailed grouse on leks is a form of recreation that has been postulated to cause disturbance. Like most other forms of recreation, little research has been directed towards this topic. Studies by Baydack and Hein (1987) and Profera (1985) suggest that disturbance at leks, regardless of the source, has the most pronounced influence on females and that continual disturbance may affect reproductive performance. Hoffman (2001) did not consider lek viewing a major threat to CSTG in northwestern Colorado because over 90 percent of the leks were on private land with little or no public access, and many of the leks on public land were inaccessible during the breeding season due to road closures or snow conditions. Hoffman (2001) also noted that CSTG appear to be more tolerant of disturbance than sage-grouse, which seldom return to the lek after they are flushed. Research and management activities for CSTG in northwestern Colorado require frequent visits to leks for inventory, monitoring, capture, and marking. Leks may be flushed three or more times in a single morning during trapping operations. Blinds are placed directly on leks within a few meters of displaying grouse to closely monitor the traps. Presence of traps and blinds do not deter males or females from attending leks. When flushed, males return within 10 to 15 minutes and often sooner. Observations of banded and radio-marked females on leks that were flushed indicate that they did not return to the lek on the

same morning, but may return on subsequent mornings. Flushing CSTG from leks does not preclude other females not on the lek at the time it was flushed from visiting the lek once the males return.

Case studies of individual CSTG leks used for viewing suggest minimal impact. Annann's Twenty Mile 1 lek is located immediately adjacent to Routt County Road 27 in northwestern Colorado. This lek is well-known within the birding community and receives frequent visitors from all over the world during the spring. This lek also was intensively trapped during spring 1999 and 2000 as part of a research study (Boisvert 2002), and it is counted two to three times every year for monitoring purposes. The counts have fluctuated since 1998 from a low of 10 males in 1999 to a high of 25 males in 2001, but the long-term trend indicates stable attendance (median = 18 males, mean = 17.7 ± 4.8 males). Similar observations at public viewing leks for greater sage-grouse in northern Colorado indicate stable or increasing lek counts (reviewed by Gunnison Sage-grouse Rangewide Steering Committee 2005). Available information suggests that viewing alone does not appear to be a threat, but it may become a threat under certain situations. When viewers engage in unethical practices, such as approaching too closely or deliberately flushing birds for pictures, or where viewing is additive to other types of disturbance, it may have negative consequences.

Purchase of 4-wheel drive vehicles and other off-road vehicles including motorcycles, snowmobiles, and all-terrain vehicles for recreational purposes has increased dramatically. Flather and Cordell (1995) predicted that by 2010 the number of people in America driving motorized vehicles off road would increase 108 percent. In the past, 4-wheel drive vehicles were primarily purchased for work, with recreational use being of secondary importance. Today, 4-wheel drive vehicles are common in rural and suburban western American households. The same is true for other off-road vehicles. Manufacturing and sale of off-road vehicles is a thriving industry that continues to grow. Although off-road vehicles are used for many purposes, their primary use is recreational. Off-road vehicles, other than motorcycles, are relatively recent forms of motorized transportation that have facilitated use of areas previously inaccessible to most people. The classic example of an off-road vehicle that has permitted this to happen is the snowmobile. Snowmobiles first appeared on the commercial market in 1962. In 1969, 290,000 snowmobiles were placed on the consumer market (Doan 1970). By 1974, snowmobile sales had grown 2,500 percent, with nearly 400 models produced by over 50 different companies (Ives 1974).

The extent of use and damage caused by 4-wheel drive and off-road vehicles in areas occupied by CSTG has been poorly documented. Erosion, slumping, soil compaction, vegetation damage, noise pollution, and harassment of wildlife have all been identified as environmental impacts of off-road vehicles (reviewed by Lodico 1973). The snowmobile perhaps more than any other off-road vehicle presents the greatest threat because it offers supreme mobility to humans at a time when many animals are least mobile. Frequent use of any off-road vehicle in areas occupied by CSTG may be an issue. Flushing of birds may increase their vulnerability to predators, unnecessarily cause them to expend energy, or temporarily displace them from optimal feeding, loafing, roosting, nesting, or breeding sites.

Coal mining

Coal is presently the major resource extracted from the landscape within the occupied range of CSTG in Region 2, but this may change as oil and gas resources are developed. Three companies mine coal within the range of CSTG in Region 2. All operate in northwestern Colorado. Surface mining has been the primary means of extraction, but one large operator has switched to underground mining. Coal mining has disturbed less than 1 percent of the landscape within the occupied range of CSTG in Region 2 and, in the long-term, it appears to have benefited CSTG in northwestern Colorado (Hoffman 2001, Boisvert 2002, Collins 2004). However, activities associated with coal mining have been identified as potential threats to CSTG, including construction of roads, power lines, railroads, buildings, and other ancillary facilities.

Reclamation practices on surfaced mined lands have improved dramatically over the past three decades due to the passage of the Surface Mining Control and Reclamation Act (SMCRA) of 1977. Boisvert (2002) found no use by radio-marked CSTG of areas mined prior to the passage of this act. In comparison, Boisvert (2002) and Collins (2004) documented extensive use during the breeding, nesting, and brood-rearing periods of lands reclaimed following the guidelines of SMCRA. Boisvert (2002) and Collins (2004) presented productivity data suggesting lands reclaimed following passage of SMCRA provided superior habitat conditions compared to native cover types and CRP, particularly for brood-rearing.

Coal mining displaces CSTG in the short term as nearly all vegetation is removed where mining occurs. Once the area is reclaimed, active leks may reappear within 10 to 15 years. Grouse may start to use the area sooner depending on the reclamation seed mixture and growing conditions (i.e., timing and amount of precipitation).

Reclamation guidelines have changed little over the years, but practices used to achieve standards set forth by the guidelines have evolved. Initially, mine operators had minimal experience in restoring plant communities. Early reclamation practices were primarily designed to control erosion and consisted of replacing the topsoil, constructing diversion ditches where needed, and seeding. Seed mixtures mainly included non-native grasses, forbs, and shrubs that were cheaper to purchase than native seed mixes. Seeds of many native species, especially forbs and shrubs, were not available, and little information existed on how to establish native species. Substantially more information and experience were available on how to establish several different species of non-native grasses and forbs. Rangeland reseeding programs using smooth brome, crested wheatgrass, intermediate wheatgrass, and alfalfa were frequently conducted by private landowners, USFS, and BLM. These non-native species were attractive to mine operators because they were easy to establish and, most importantly, became established quickly, which was considered essential for controlling erosion.

While mine operators achieved some success establishing non-native grasses and forbs, they had minimal success establishing shrubs. The common practice was to drill shrub seeds into the soil along with grass and forb seeds. Few shrubs were successfully established using this approach. Grasses and forbs usually outcompeted shrubs, especially where more aggressive non-native grasses were planted. In many areas, the most abundant shrub on the landscape prior to mining was big sagebrush. Mine operators excluded this species from seed mixtures because it was considered undesirable from a rangeland perspective. Thus, the primary outcome of early restoration efforts was the conversion of sagebrush and mountain shrub dominated communities to grasslands dominated by non-native grasses. Wildlife managers viewed this outcome as being negative for wildlife.

Considerable changes have occurred in reclamation practices since passage of SMCRA. Seeds of native species are now readily available on the commercial market at reasonable prices, and research studies have provided valuable information on how to establish native grasses, forbs, and shrubs (Monsen 2005). Boisvert (2002) and Collins (2004) each identified over 90 different species of grasses (25 species), forbs (59 to 61 species), and shrubs (7 to 11 species) in mine reclamation lands used by CSTG in northwestern Colorado. Approximately 50 percent of the identified plants were native species. Not all species identified were part of the original seed mixtures, indicating natural colonization had occurred on the reclaimed sites, particularly by forbs.

The greatest potential threat to CSTG with respect to mine reclamation lands is what will happen to these lands over the long term after bond release (Hoffman 2001). Regardless if the mines retain ownership or the lands are sold or revert to the original owners, there are no guarantees to assure these lands will be managed in ways that are beneficial or at least not detrimental to CSTG. In most cases, reclaimed lands that have received bond release are leased for grazing. The possible detrimental impacts of grazing and its associated practices (e.g., fencing and herbicide treatments) have been previously addressed. Impacts of most concern are reduction of residual cover important for nesting in spring, reduction of new herbaceous growth during late spring and summer important for nesting and brood-rearing, and reduction or loss of desirable forbs important as food and as a source of insects for chicks. Also of concern is the spread of noxious weeds. Of the 90 different plant species identified on mine reclamation lands by Boisvert (2002) and Collins (2004), at least 10 were classified as invasive, undesirable species. At the time these studies were conducted, no invasive species were threatening established plant communities within the areas still under bond (i.e., no grazing). This was due, in part, to an aggressive weed control program by the mine operators. Another reason was that healthy plant communities already established on these areas kept the weeds from spreading. Any significant alteration of these communities, whether due to improper grazing or some other form of disturbance, may promote the spread of noxious plants on mine reclamation lands.

Hunting

Hunting is a form of recreation that results in direct disturbance and exploitation of CSTG. Currently, CSTG are legally hunted in Colorado, Utah, Idaho, and British Columbia. Hart et al. (1950) identified unregulated hunting as one of the major contributing factors leading to the decline of CSTG. Tirhi (1995) reported that regulated hunting likely has little effect on the stability of healthy CSTG populations. At the

other extreme, Marks and Marks (1987) and Ritcey (1995) cautioned against allowing hunting of small, isolated populations. In Utah, populations continued to decline despite a closed season for 25 years (Hart et al. 1950). Likewise, closed seasons in Washington (Tirhi 1995), portions of Idaho (Marks and Marks 1987), and Wyoming (Oedekoven 1985) have not resulted in recovery of populations in these areas. Hoffman (2001) provided data indicating that hunting removed less than 4 percent of the fall population in northwestern Colorado. At this level of harvest, Hoffman (2001) considered hunting mortality was compensatory to natural mortality, but suggested overharvest may occur on public lands.

Bergerud (1988b) argued that hunting at any level may be additive to over-winter mortality of grouse. Several other investigators have presented data indicating that hunting of grouse is partially, if not totally, additive to natural mortality (Braun 1969, Ellison 1991, Small et al. 1991, Steen and Erikstad 1996, Smith and Willebrand 1999). Ammann (1957) concluded that prairie sharp-tailed grouse in Michigan could sustain a harvest of 40 to 50 percent of the fall population on large areas of optimum habitat during naturally increasing or stable population trends. In contrast, Amman (1957) reported that on isolated areas of limited size or on areas with below optimum habitat where populations were declining, hunting depressed populations to a greater extent than would naturally occur without hunting.

The argument that if hunting is additive, then subsequent breeding populations should decline is not valid. Immigration from non-hunted or lightly hunted areas may sustain densities on some heavily hunted areas (Small et al. 1991, Smith and Willebrand 1999). As a result, effects of hunting may go undetected or hunting may be interpreted as having no impact because breeding densities remain stable. This may be happening on some public hunting areas in northwestern Colorado.

Public hunting opportunities for CSTG in northwestern Colorado are limited due to the preponderance of private lands. Hoffman (2001) suggested that this may result in overharvest in the few areas where CSTG occur on public lands. Giesen (1997) reported that California Park accounted for approximately 30 percent of the total CSTG wings collected in northwestern Colorado from 1981 to 1997. California Park is one of the few places in northwestern Colorado where CSTG occur on USFS lands during the fall hunting season. Many hunters using this area are familiar with the habits of the birds and know how and where to look for them. USFS personnel responsible for management of this area have expressed concern about possible overharvest of this population (R.C. Skorkowsky personal communication 2005). No data are available to support or refute this concern. Counts of known leks in California Park have shown no long-term decrease or increase in the population (Colorado Division of Wildlife, unpublished data). However, as reported by Small et al. (1991) and Smith and Willebrand (1999) for other species of grouse, it is possible the California Park population and other heavily hunted populations on public land are maintained by immigration of birds produced on surrounding private lands.

Another reason for concern about overharvest on some public lands, such as California Park, is that not all public lands in northwestern Colorado open to hunting are accessible to the public or support CSTG. Some of best habitats for hunting CSTG on BLM lands are surrounded by private holdings and cannot be accessed by public hunters. Many of the BLM lands that are accessible to the public are at lower elevations within the sagebrush zone. These areas support low densities of CSTG and provide marginal hunting opportunities. Leasing of State Trust Lands by the CDOW since 1993 has provided additional areas for the public to hunt CSTG. This has alleviated some pressure on the more heavily hunted federal lands. However, CSTG on the better-known State Trust Lands may now be subject to overharvest.

Climatic factors/global climate change

All species of grouse are sensitive to annual fluctuations in weather conditions. Weather (Shelford and Yeatter 1955, Yeatter 1963) and vegetation production (Kirsch et al. 1978) are two of the foremost factors influencing production of prairie grouse. Of these two factors, weather probably has the single most pronounced influence because it also affects vegetation production. Weather can affect grouse production in three primary ways:

❖ by decreasing nest success and chick survival due to poor cover

❖ by decreasing food availability due to lack of forbs and insects

❖ by direct mortality of chicks due to chilling or heat stress.

The effects of weather on grouse populations are multifaceted, which is why attempts to show a relationship between a single weather variable and production indices often fail. Such simple associations do not adequately address the complex relationships among numerous weather factors that influence grouse production (Flanders-Wanner et al. 2004).

Northwestern Colorado and south-central Wyoming can experience extreme climatic conditions during all seasons. While the avifauna present in this region is adapted to these conditions, adverse effects can occur during prolonged periods of below or above average precipitation and temperatures. Cold, wet springs that coincide with the peak of hatch can decrease production. On the other hand, if above average moisture occurs before hatching, the resulting increased vegetation growth needed for cover and food can enhance grouse production. Bergerud (1988a) reported that productivity of sharp-tailed grouse in North and South Dakota was positively correlated with an index to soil moisture. Collins (2004) reported that severe drought conditions during 2002 contributed to low nesting success and poor chick survival of CSTG in northwestern Colorado. The effects of the drought differed between cover types. Brood success and chick survival in mine reclamation declined from 2001 (moderate drought) to 2002 (severe drought). Brood success and chick survival remained low during both years in shrubsteppe, suggesting that within this cover type these reproductive parameters may have been affected by the moderate as well as the severe drought more than in mine reclamation. In north-central Nebraska, May average temperature, June average temperature, and cumulative precipitation from 1 January to 31 July were positively correlated with sharp-tailed grouse production, while June number of heat stress days and June number of days with precipitation over 2.54 mm were negatively correlated with production (Flanders-Wanner et al. 2004).

The impacts of weather on sharp-tailed grouse production are beyond management control. Naturally-occurring weather extremes are to be expected and generally only have temporary impacts on grouse populations. Species, such as sharp-tailed grouse, with high reproductive rates can quickly recover from extreme weather events. However, for small, isolated populations living in marginal habitats, the effects of weather may be more severe and long-lasting.

Not all weather-related events that affect grouse may be the result of natural weather phenomena. Global climate change is a major conservation concern that is predicted to affect the structure and functioning of ecosystems worldwide (McCarty 2001, Walther et al. 2002, Parmesan and Yobe 2003, Krajick 2004). These studies emphasize that additional threats will emerge as climate continues to change. The new threats will be most pronounced where climate interacts with other threats such as habitat degradation and fragmentation. Although the effects of climate change have yet to be rigorously demonstrated, available data suggest that the prudent course of action is to take the effects seriously (McCarty 2001).

Future climate scenarios show two prominent features in the West: increases in temperature, hence a decrease in frosts; and increases in precipitation (Bachelet et al. 2001). Increases in temperature are predicted to have a long-term impact on species composition of the shrubland ecosystem. Temperature increases will likely move the frost line north, allowing frost-sensitive species of the southwest to move north and displace the cold-adapted species growing in the shrubland ecosystem (Neilson et al. 2005). Models further predict that increases in precipitation will produce dramatic increases in woody (i.e., conifers) expansion at the expense of shrublands (i.e., sagebrush and mountain shrub) throughout the Interior West, and a corresponding increase in fire due to increased fuel loads (Neilson et al. 2005). The increase in fire does not contradict the expansion of conifers because fires will not occur everywhere at all times. Sufficient fire-free intervals will exist for conifer establishment. The timeline for these predicted changes to occur is unknown as are the consequences to CSTG. However, human mismanagement of habitats occupied by CSTG could compound and accelerate the effects of climate change.

Management Activities for Columbian Sharp-tailed Grouse in Region 2

Implications and potential conservation elements

Loss of CRP is the most important immediate threat to CSTG populations in Region 2. One of the primary reasons the USFWS did not list the CSTG as threatened or endangered in 2000 was because three states, including Colorado, provided evidence that populations were stable or increasing due to the implementation of the Conservation Reserve Program. In their 12-month finding, the USFWS specifically discusses the importance of CRP to CSTG and partially justified not listing the CSTG because they concluded CRP lands were relatively secure until 2008 to 2010

when the contracts would expire (U.S. Department of Interior 2000). Failure to recognize the precarious nature of the Conservation Reserve Program was short-sighted on the part of the USFWS. The USFWS acknowledged that if CRP lands important to smaller populations of CSTG reverted to crop production or were significantly altered in other ways (i.e., grazing or haying), this would greatly increase the risk of extirpation. However, they did not believe the larger metapopulations were in danger of extirpation and suggested these populations would not be adversely affected by loss of CRP. Although these populations should persist without CRP, the available data suggest they would experience drastic declines, especially in states such as Utah where native cover types are limited in distribution and degraded due to excessive grazing (Utah Division of Wildlife Resources 2002). Population declines also can be expected to occur in Colorado, Washington, and Idaho. That CSTG are so dependent on an artificial cover type that can be eliminated with a change in the farm program is reason for concern and emphasizes the need to protect, enhance, and restore native cover types important to CSTG. This was a major premise of the second petition that was filed to list the CSTG (Banerjee 2004).

It is anticipated that within the next three to five years, oil and gas exploration and extraction could be the single most threatening activity on lands occupied by CSTG in Region 2 if these resources are developed to their fullest potential. Compared to the coal industry, regulations governing the oil and gas industry are less restrictive and inadequate to insure proper reclamation and compliance with environmental concerns. The ability to enforce existing laws and personnel to make enforcement effective are lacking. Because the situation changes over time, there is no easy way to predict the extent of disturbance on the landscape from oil and gas activity and to develop effective mitigation and restoration measures. The oil and gas industry has adopted a policy to mitigate impacts to wildlife, but participation is voluntary. Furthermore, even though oil and gas companies are required to post bond when removing federally owned minerals, bonds may be insufficient to insure that disturbed sites are fully reclaimed. Companies may change ownership, or larger companies may sell their leases to smaller companies. Thus, it is not clear who is liable for reclamation. There is also concern that if small companies purchase the leases, they may have insufficient means to restore the landscape. Over the long term, it may be cheaper for companies to forfeit their bond money than to complete reclamation. Finally, the regulatory agencies

in Colorado and Wyoming responsible for overseeing the oil and gas industry (Oil and Gas Commission) are mandated by law to promote oil and gas resources in their respective states. This conflict of interest seriously hampers the regulatory process. An agency responsible for promoting energy development cannot at the same time effectively protect public health, safety, and welfare, which includes protecting other resources (e.g., wildlife) that may be impacted by oil and gas activity.

On their website (http://oil-gas.state.co.us/general/typquest.html, accessed 4 November 2006), the Colorado Oil and Gas Commission claims that impacts of oil and gas development on wildlife are relatively small and benign because a well only affects an area of approximately 1 ha. The Commission fails to address the impacts of multiple wells and associated infrastructure (roads, power lines, pipe lines, compressor stations, collection stations) required to maintain wells and to move the product to market. They report that CDOW wildlife biologists have confirmed that gas wells developed at one well per 16 ha (40 ac) typically have less impact on wildlife than 14 ha (35 ac) ranchette developments. This comparison is an attempt to minimize the impacts of oil and gas development by comparing it to another type of development that is known to have serious impacts to wildlife. Wildlife managers presently do not have rigorous data to support their concerns about oil and gas development. Consequently, the oil and gas industry has proceeded with developments using the argument that there are no data to conclusively demonstrate negative effects to wildlife. The burden of proof has fallen on wildlife and land management agencies. If the oil and gas industry truly believes their activities have no impacts to wildlife initially or in the long term, they should assume the responsibility of collecting data to support their contention (Braun et al. 2002).

Historically, unregulated and widespread grazing posed the greatest threat to CSTG in Region 2. Data obtained from the National Agricultural Statistics Service indicate that over the long term (50+ years), both sheep and cattle numbers have declined in counties where CSTG still occur in Region 2. Despite the overall reduction in domestic livestock, grazing remains an issue of concern in Region 2. Few areas within the occupied range of CSTG in Region 2 are not grazed, especially on public lands, and basically no effort has been made to rest formerly overgrazed ranges. Consequently, the effects of past grazing practices are still evident throughout Region 2. Ungrazed rangelands encompass less than 20 percent of the occupied range

of CSTG in Region 2, and critically important habitats continue to receive excessive grazing pressure to the detriment of CSTG.

Having the option to alter grazing patterns from year to year would alleviate some of the problems associated with grazing. However, most CSTG habitats in Region 2 are snow-bound from December through March. Therefore, most grazing pressure on habitats occupied by CSTG in Region 2 occurs during the growing season and continues into the fall (i.e., from mid-May through mid-September). Thus, livestock are on the range every year during the critical periods when CSTG are nesting and raising their broods.

Livestock grazing is perhaps the most contentious, politically sensitive, and polarizing issue facing those responsible for management and conservation of prairie grouse in North America. The debate centers around the lack of empirical data on effects of grazing on grouse. There are no published studies on the effects of livestock grazing on CSTG based on manipulative experiments designed to measure cause-effect relationships. However, extensive information does exist on impacts of grazing on plant communities (i.e., sagebrush and mountain shrub) of critical importance to CSTG (reviewed by Saab et al. 1995, Trimble and Mendel 1995, Connelly et al. 2004, Gunnison Sage-grouse Rangewide Steering Committee 2005, Monsen 2005). This information has been used for making inferences about the negative impacts of grazing on CSTG (Hart et al. 1950, Parker 1970, Zeigler 1979, Klott 1987, Marks and Marks 1987, Giesen and Connelly 1993, Tirhi 1995, Schroeder et al. 2000, Hoffman 2001, Utah Division of Wildlife Resources 2002). In surveys conducted by Miller and Graul (1980) and Kessler and Bosch (1982), respondents identified past and present overgrazing as the highest ranking factor suppressing CSTG populations.

With regards to grouse management, grazing can be a compatible and acceptable use of the landscape when done properly. Private lands provide the majority of CSTG habitats in Region 2. The primary use of these lands is for grazing. Healthy and productive rangelands are the foundation for both abundant wildlife and a profitable and sustainable ranching industry. Emphasis should be placed on maintaining these lands as viable economic units to preserve large areas of habitat for CSTG. The alternative is habitat fragmentation and increased human impacts when rangelands are sold for development.

In the past, conversion of native habitats for other uses, particularly croplands, was considered the second greatest threat to CSTG in Region 2. Due to topographic constraints, habitat conversion for agricultural purposes has had less of an impact on CSTG populations in Region 2 than elsewhere throughout the subspecies' range (Hoffman 2001). The loss of habitat to agriculture in portions of Region 2 has been partially and temporarily alleviated because extensive areas of cropland have been converted to CRP (Hoffman 2001, Rodgers and Hoffman 2005). Hoffman (2001) estimated that agricultural lands (primarily wheat, alfalfa, and hay) comprise about 18 percent of the occupied range of CSTG in northwestern Colorado. The proportion of agricultural lands within the range of CSTG in Wyoming is less than 5 percent. The difference is due to the absence of wheat farming in south-central Wyoming. Unlike in Colorado, cultivated land in Wyoming is generally restricted to areas adjacent to river bottoms with little upland tillage. Further conversion of native habitats to croplands is not expected to occur in Region 2, but habitat loss is likely to occur because of other activities, including urban and rural expansion and energy development.

Rosenberg et al. (2004) estimated recreational use on lands administered by the USFS has increased 76 percent since 1976. Former USFS Chief Dale N. Bosworth identified unmanaged recreation as one of the four major threats to the health of the nation's forests and grasslands (www.fed.us/projects/four-threats, accessed 9 October 2006). There is no evidence to suggest that present levels of recreation are affecting CSTG populations in Region 2, except possibly in localized areas. Of concern, however, is that the level of activity will continue to increase, and that conflicts between recreationists and wildlife will escalate in Region 2. The many types of recreational activities are in themselves a problem. Managers have the difficult task of trying to regulate the many different ways people recreate. It is much easier to focus on one group as evidenced by the recent proposed regulations to manage off-road vehicle use on national forest and grasslands (U.S. Department of Agriculture 2004). Recreational activities such as skiing, hiking, and off-road vehicle use may cause minimal or only localized conflicts with wildlife, but their combined effects may cause significant disturbance or habitat degradation. Managing one form of recreation to minimize conflicts with wildlife without simultaneously considering the other types of recreation occurring in the area may not solve the problem.

People with more expendable income and leisure time will continue to move into Region 2 and will be seeking new and different ways to recreate. This will place additional demands on the limited amount of public lands within the occupied range of CSTG in Region 2. Since sagebrush and mountain shrub communities in Region 2 support a diverse array of wildlife species, including three species of grouse, they are becoming a popular destination for ecotourism, a form of organized recreation that brings tourists to biologically rich and unique ecosystems. Presently, at least nine different commercial tours visit northwestern Colorado each spring to observe CSTG on leks.

The threat of overharvest of CSTG on public lands may become more widespread and pronounced as human populations grow and opportunities diminish for hunting other grouse species. Whether hunting impacts the rate of growth of CSTG populations remains a subject of debate. It is not known to what extent fall hunting is compensatory or additive to natural mortality. Sharp-tailed grouse are short-lived, lay large clutches, attempt to nest as subadults, and are relatively good re-nesters; these traits suggest that hunting may be more compensatory than for longer-lived and less productive galliforms, such as Gunnison and greater sage-grouse. However, this situation may only apply to healthy populations distributed over large areas of optimum habitat. Columbian sharp-tailed grouse in Region 2 are not as widely distributed as they were historically, and conditions in the remaining native habitats may be less than optimal. What effect this may have on the impacts of hunting is unknown. Given the declines in CSTG populations and distribution throughout its range, Carlton (1995) and Banerjee (2004) challenged the justification for the continued sport hunting of this subspecies of sharp-tailed grouse.

Global warming should be recognized as a serious threat to the long-term persistence of CSTG in Region 2 and throughout the subspecies' range in western North America. Global climate change could have consequences on a larger scale than the combined effects of all the other activities threatening CSTG. The critical issue is no longer if global warming is occurring, but rather how to slow and eventually reverse its effects on wildlife and the plant communities upon which they depend. Climate research throughout the world suggests that global warming will likely continue for decades even if steps are taken now to address the problem.

Global warming, energy development, rural and urban expansion, fire suppression, recreation, and most of the other activities identified in this assessment as threats to CSTG are symptoms of the much greater problem of human population growth. The human population in the United States recently surpassed 300,000,000 people. Burgeoning human populations are placing an increasing demand on the landscape for more resources, ways to make a living, places to live, and places to recreate. Addressing the human population issue is beyond the scope of this assessment, but failure to mention it perpetuates the illusion that ways can be found to maintain wildlife populations and their habitats in spite of growing human populations. Regardless of scientific and technological advances, wildlife habitats will continue to decline and sustain irreparable damage if human population growth is not managed.

One only needs to review the conservation status of grouse in Europe and Asia (Storch 2000) and the history of the heath hen (*Tympanuchus cupido cupido*) on the Atlantic coast and Attwater's prairie-chicken (*T. cupido attwateri*) on the Gulf coast (Johnsgard 2002) to predict the fate of grouse elsewhere in North America if human populations continue to grow. This is not a criticism of those responsible for conservation and management of grouse and their habitats. The wildlife profession has tried to bring attention to this matter, but to no avail (see position statements by The Wildlife Society on human populations and economic growth at http://.wildlife.org, accessed 4 December 2006). Columbian sharp-tailed grouse are in the direct path of growth and development. Unless the situation changes, to expect that wildlife managers can develop strategies to increase or even maintain CSTG populations at their present levels is wishful and irrational thinking. The best that can be expected is to prevent the subspecies from becoming extirpated and to retain a few viable populations on the landscape. This is the management approach for CSTG in several western states and has been the management strategy for black grouse and capercaillie in many countries in Europe for several decades (Storch 2000).

Tools and practices

Inventory and monitoring populations

Tirhi (1995) listed six survey methods used for monitoring sharp-tailed grouse populations: lek counts, lek surveys, dropping counts, strip census, brood surveys, and winter counts. Three additional survey methods not discussed by Tirhi (1995) are lek routes (Connelly et al. 2003), wing collections (Giesen 1999), and lek densities (Cannon and Knopf 1981).

Lek counts: Lek counts are an enumeration of the number of grouse identified on leks. They provide information on total and average number of males per lek and total and average number of birds per lek. Lek counts are best conducted from ½ hour before sunrise to 2 hours after sunrise during the peak of breeding activities (mid-April to mid-May in Region 2) on mornings with no precipitation and wind speeds less than 16 km per hour.

Attempting to count leks from an aircraft is not recommended. Sharp-tailed grouse are difficult to detect from the air, and their response to an approaching aircraft will vary. They may crouch and become inconspicuous on the lek. Others may flush or retreat to taller cover. The most efficient way to count leks is from a vehicle. This is not always possible for counting CSTG leks in Region 2 because there are frequently no roads within clear sight of the lek, or the roads are impassable due to mud or snow. Obtaining an accurate count is compounded by the fact that the birds are often obscured by vegetation or the lek is on a knoll or ridge where it is difficult to find a vantage point to view the entire lek. For many leks in Region 2, a flush count is the only way to obtain an accurate count. Flush counts are an acceptable method for counting leks as males generally return to the lek within 10 to 15 minutes after being flushed. Males can be counted as they fly back to the lek, but more often, some males return by flying while others walk. Birds that walk back can easily go undetected. If females are present on the lek, they usually will not return once flushed. However, other females may visit the lek after the males return.

If the observer has a clear view of the lek, females can be counted separately from males based on their behavior. Once the birds are flushed, it is not possible to identify males from females. Females move freely through the lek and tend to congregate in small groups near the center of the lek. Females do not perform any type of obvious displays when they are on the lek and exhibit little or no aggressive behavior towards each other or males. Males are distributed across the lek, seldom venture off their territories, and vigorously display and call in the presence of females. Aggressive interactions between neighboring males are common. Males not in the immediate presence of a female will perform flutter jumps in an effort to attract the female's attention. Without having a full view of the lek, an experienced observer can still ascertain if females are present by noting the behavior of the males. The observer can consider this information when needing to conduct a flush count. When the lek is approached, females will usually be the first to flush. The males

will generally hold longer and flush as a group. A few stragglers may remain on the lek until the observer gets closer and then flush. If an observer notes little or no activity on the lek prior to conducting a flush count, it is reasonable to assume no females are present.

Lek surveys: Lek surveys are used to find newly-formed leks and previously unidentified leks and to learn if leks have moved to a new location. Lek surveys are usually conducted in conjunction with or secondary to lek counts. Since the primary goal of lek surveys is to find leks, they can be conducted anytime that males are attending leks. The best time to conduct lek surveys is during the peak of breeding activities when males are most active and easiest to detect. Lek surveys can be conducted on foot, by horseback, and from motorized or non-motorized ground vehicles (e.g., mountain bike, trail bike, truck, ATV). Lek searches from aircraft are only practical when snow covers most or all of the ground. Even then, small leks and leks in tall vegetation can be easily missed.

Lek searches conducted only from roads may not be as effective as surveys conducted both on and off roads. Unless roads traverse along ridge tops or across other high points, it may be difficult to hear or see birds on leks. Smaller leks (<12 males) are more difficult to find than larger leks. The standard approach for conducting lek surveys is to walk or drive through suspected or known breeding habitat and to stop approximately every 0.5 km to listen and scan for displaying males. Males may initially stop displaying and calling at the approach of a vehicle. Therefore, the observer should turn off the engine, step from the vehicle, and listen and scan the surroundings for at least 5 minutes before proceeding to the next stop. On calm mornings, males may be heard calling from up to 1 km away. Similarly, the white under tail coverts of displaying males and males performing flutter jumps can be spotted with binoculars or a spotting scope from distances over 1 km. When scanning the surrounding landscape, the visual search effort should focus along ridge tops, knolls, benches, and broad, flat expanses. Observers should watch for birds flying and note where they land. They could be females flying to a lek or males returning to a lek after being flushed by a predator.

Occasionally, lek sites can be located when birds are not present. An abundance of droppings and feathers (lost during skirmishes between males) typically occur on leks, and distinct paths are evident on the ground where the males stomp their feet while displaying. Patches of bare ground and worn vegetation are apparent across the lek site, especially near the center

where activity is the greatest. Tracks may be imprinted into the bare ground from when the males displayed on wet mornings. It is possible to locate the actual lek site by searching areas suspected of supporting a lek for evidence of these features.

Dropping counts: Dropping counts are used to ascertain presence of grouse in an area. The basic sampling approach is to establish random transects of a specific length. Plot frames of a fixed size and shape (circle or rectangle) are placed on the ground at pre-selected intervals along each transect and searched for droppings. The number of droppings within each plot and total number of droppings along each transect are recorded. These measurements provide an indication of the intensity of use of the area sampled. No reliable method has been developed to relate number of droppings counted to number of birds that produced those droppings. Thus, measurements cannot be used to make inferences about the density of grouse using the area. Investigators conducting dropping counts in Region 2 must be aware of the presence of other grouse species and have the ability to identify their droppings from those of CSTG.

Strip (transect) census: Data obtained from a strip census are used to calculate an index of density. A strip census is conducted by walking a series of transects of fixed length and width and recording the number of birds flushed. Using a trained hunting dog increases the efficiency in finding and flushing grouse. Another approach is to use several observers and have them drag a rope or light chain between them. The strip census provides an estimate of the density of grouse per unit of area searched. To obtain a valid density estimate, transects must be randomly located and sample all known cover types that may be used by CSTG in the area being searched. Strip census also can be used to obtain density estimates within a specific cover type. For instance, transects can be randomly located but limited only to CRP lands within the search area. Transects must be located in a manner that minimizes the chances that grouse flushed and counted on one transect fly to another transect where they are later flushed and counted again.

Brood surveys: Brood surveys are conducted by driving established routes through known brood-rearing and summering areas during early morning (sunrise to 0900 hrs) and evening (1800 hrs to sunset) and recording the number of broods observed, number of chicks observed per brood, and number of other (i.e., males or females unaccompanied by chicks) birds observed. This information can be converted into birds

observed per km, broods observed per km, average brood size, and chicks observed per adult. Data obtained on brood routes for CSTG cannot be used to estimate the ratio of successful to unsuccessful females due to the similarities between males and females. Unless an adult grouse observed on the route is accompanied by chicks, it is not possible to ascertain if the bird is a male or female.

Brood surveys are conducted in early August when chicks are sufficiently large enough to fly but small enough so they can be distinguished from adults. The routes should be completed within a 2-week period or less. Extended sampling periods may create bias due to changes in behavior and distribution of birds. The observer first attempts to count the birds from the vehicle and then exits the vehicle and walks through the area to count birds as they flush. Some chicks will hide and hold tight rather than fly. Use of a trained hunting dog will increase the observer's ability to locate chicks. Collins (2004) found that use of a trained hunting dog after completion of a traditional flush count without the dog resulted in 16 percent more chicks being flushed.

Routes should not exceed 35 km in length and should be driven at about 20 km per hour. This will allow sufficient time to flush and count any birds observed and still complete the survey in less than three hours. Due to their length, brood routes must be conducted from a motorized vehicle. Only one person is needed for each route. Attempts to conduct brood routes for CSTG have had limited success. Rogers (1969) reported finding only one CSTG brood along 521 km of brood routes surveyed in Colorado during the first two weeks of August. Rogers (1969) attributed his lack of success to the scattered distribution and low densities of CSTG in Colorado during the early 1960's when he conducted his investigation.

Detection rate also may have had a part in Rogers (1969) lack of success in finding broods. The wary nature and secretive habits of CSTG broods along with the dense cover used for brood-rearing habitat are factors that contribute to their low detection rate. The types of roads over which the surveys are conducted also can be important. Columbian sharp-tailed grouse likely avoid well-traveled roads and roads bordered by fences or utility lines that offer perching sites for avian predators. Shorter routes that can be intensively searched on foot with dogs may be a better approach to conducting brood surveys than surveys conducted from vehicles along established roads. Even this approach may not produce sufficient observations. Over two summers of searching for broods with a dog from early June to late August,

Klott (1987) only flushed 44 CSTG broods, of which 16 flushes were of previously observed broods (total individual broods encountered = 28).

Winter counts: Winter surveys are conducted primarily to identify wintering areas and secondarily to count the number of birds using these areas. No standardized method has been developed for assessing winter populations. In states where winter habitat is limiting and readily accessible, conducting winter counts may have some merit in assessing populations, especially when snow cover prevents the birds from feeding on the ground and causes them to use riparian corridors where they feed in shrubs above the ground. Under these conditions, birds are more conspicuous and relatively easy to observe and count.

Winter surveys are probably not a viable option for assessing CSTG populations in Region 2 for several reasons. Columbian sharp-tailed grouse can be extremely difficult to locate in winter in Region 2, as winter habitat does not appear to be limiting (Hoffman 2001). Further, studies in Region 2 suggest that the birds are distributed over large areas during winter (Collins 2004, Boisvert et al. 2005). Perhaps the main obstacle to conducting winter surveys in Region 2 is access. Columbian sharp-tailed grouse in Region 2 primarily winter above 2,100 m elevation where snow cover commonly exceeds 100 cm from December through March. Access even by snow machine can be difficult due to lack of packed trails and steepness of the terrain. The value for conducting winter surveys in Region 2 would be to gather information on the location of important wintering areas.

Lek routes: Lek routes are a form of lek count with the distinction that a lek route is an attempt to count a group of leks in one morning that are relatively close together and are believed to represent part or all of a single breeding complex. Lek routes are most practical in areas with a network of accessible rural roads that allow the observer to cover long distances within a single morning. Applegate (2000) observed that roads are not randomly distributed and lekking grouse may avoid certain types of roads. This could lead to biases in interpretation of the data obtained from lek routes.

Lek routes are used to survey known leks, to locate new leks that become established along the route, and to ascertain if known leks have changed locations. On lek routes, an observer ascertains the presence of active lek sites by driving along a standardized route and stopping the vehicle (turn off the engine) and listening at periodic intervals for the vocal sounds of displaying males. Routes are usually 16 to 32 km long, with listening points at 0.5 to 1 km intervals. The same route is run every year. The direction and approximate distance to all audible leks are recorded. All leks detected along the survey route are visited (preferably the next morning), and the number of birds present is recorded. In addition, all lek sites known to be active in previous years, but not detected during the survey, are visited to learn if they are still active or if the lek site has moved to a new location. If another lek is located within 0.5 km of an inactive site, it should not be classified as a new lek.

Wing surveys: Collection and analysis of wings obtained from hunter-harvested birds can be used to assess reproductive performance in grouse populations (Hoffman 1985, Giesen 1999). Wings are collected at hunter check stations or operation of volunteer wing collection stations placed at strategic access points to popular hunting areas (Hoffman 1981). The validity of using information obtained from wing samples to draw conclusions about the population is based on the assumption that different age and gender classes are harvested in proportion to their occurrence in the population. This assumption has not been tested for CSTG. Unwary juveniles may be more vulnerable to harvest than adults are or males may be more vulnerable than females due to their tendency to return to leks in the fall.

A major challenge of wing collections, particularly for lightly hunted populations, is obtaining an adequate sample of wings. Giesen (1999) reported data on CSTG populations based on wing samples collected over a 22-year period from 1976 to 1997. Samples exceeded 100 wings in only eight of 22 years. Another limitation of wing collections with regards to CSTG is that no reliable technique has been developed to distinguish females from males based on wing characteristics. Despite these limitations, two potentially useful indices of productivity that can be derived from the analysis of CSTG wing samples are percent juveniles in the harvest and the ratio of juveniles to adults (includes yearlings). Wing data should not be used to make inferences about population trends. The data are best used to complement information collected using other survey methods.

Lek densities: Cannon and Knopf (1981) suggested that lek density, instead of the number of males on leks, could be used to derive a lek index that reflected population changes. They found that the number of leks of lesser prairie-chickens exhibited a strong positive correlation with density of displaying males. In comparison, average lek size was highly

variable at high population densities. The increased variability in average lek size was attributed to formation of numerous, small, temporary leks at high population densities. When these small, temporary leks are factored into the computations, average lek size may not change or could possibly decrease.

The problem with this approach as addressed by Schroeder and Braun (1992) is that lek densities can be difficult to estimate and seldom are obtained with a corresponding estimate of precision. Part of the problem is that leks are not equally detectable due to their size and topographic position on the landscape. Measurement of lek densities for CSTG would be extremely labor intensive, except on small areas. To search large areas to derive a regional estimate of lek densities would require use of aircraft. For reasons already discussed, CSTG leks cannot be accurately located from the air. Thus, large areas would need to be intensively searched on the ground. Even if this was possible, numerous other factors including weather during the survey, timing of the survey, disturbance by predators, and observer bias may influence the ability to detect leks.

Lek counts revisited: Of the survey methods discussed, lek counts appear to offer the best opportunity for monitoring CSTG populations. Leks are relatively easy to locate, observe, and count, which is why lek counts have become an integral part of prairie grouse management programs. However, lek counts are not without problems. Investigators have questioned the validity of using lek counts as a tool for estimating population trends because of known variations in lek attendance patterns among male prairie grouse (Beck and Braun 1980, Robel 1980, Applegate 2000, Anderson 2001, Walsh et al. 2004). These investigators did not advocate that lek counts be discontinued. Instead, they recommended that studies be conducted to better understand the problems associated with lek counts and possibly to develop correction factors to derive a more rigorous index to population change using lek counts.

Walsh et al. (2004) recommended that lek counts can be improved upon by minimizing sources of variation through standardization of counting protocols and by using trained observers to conduct the counts. They prefaced their recommendations by noting that until lek counts are calibrated to population parameters by estimating detection probability, managers must realize the limitations of lek count data. Walsh et al. (2004) further noted that estimating the number of unknown leks is another essential component of allowing lek counts to be properly related to population size and trends.

Walsh et al. (2004) proposed the use of a modified sightability model as an option for correcting lek count data and for estimating population size of greater sage-grouse on known leks. The correction technique requires a specific set of design criteria to obtain the required data. The technique can only be applied to a geographically closed population, individual birds must be radio-marked prior to lekking season, observers must monitor the marked birds daily throughout the lekking season, and counts of all known leks must be conducted concurrently with the monitoring of marked birds.

The size (>250 known leks) and distribution (>7,800 km^2) of the CSTG population in Region 2 preclude any possibility of developing a sightability index model for correcting lek counts. No effective technique has been developed for capturing CSTG outside the lekking season. Techniques used to capture other grouse during periods when they are not attending leks, such as baiting or night-lighting during winter, have proven unsuccessful in capturing CSTG. Until a technique is developed, it will not be possible to conduct an unbiased assessment of CSTG lek attendance patterns, estimate the number of unknown leks, or develop a sightability index model for correcting lek counts. However, if a way is found to capture CSTG other than during the lekking season, it may be feasible to develop sightability models for estimating population size of CSTG in smaller areas where they have been recently transplanted in Region 2.

Inventory and monitoring habitats

Habitat characterization for CSTG should follow the processes described by Johnson (1980) as recommended by Connelly et al. (2003) for greater sage-grouse and Robb and Schroeder (2005) for greater prairie-chickens. Johnson (1980) described habitat selection as a hierarchical process and used different levels of selection to illustrate this process. First-order selection represents habitat characteristics within the geographic range, second-order selection represents habitat characteristics of the home range, third-order selection represents use of different habitat components within the home range, and fourth-order selection represents habitat characteristics of particular use sites (i.e., feeding, loafing, escape, nesting, and brood-rearing). The orders range from macro- to micro-scale components for habitat selection. Analysis of habitat use at both scales is important for understanding animal-habitat relationships. For CSTG in Region 2, studies have focused on macro- (first and second order selection) and micro-scale (third and fourth order selection) habitat components of seasonal

use areas, but macro-scale components are probably more clearly described and understood than micro-scale components.

At the regional scale, habitat data can be collected from maps, aerial photographs, and satellite imagery. Data obtained from these sources seldom reveal any information about condition of the habitat. In addition, since it may be difficult to distinguish among some land-cover classes, caution must be exercised in interpreting the data. For example, cover types of known importance to CSTG, such as CRP and mine reclamation, may not be distinguishable from cover types of less importance, such as pasture, hayfields, and certain crops. Collecting data from maps, aerial photos, and satellite imagery is often a necessary starting point for identifying the distribution of cover types important to CSTG. Aerial photographs and satellite imagery can be used to refine this information by discerning the extent of fragmentation across the landscape and by revealing changes in the landscape over time. Aerial photographs and satellite imagery in combination with Geographic Information System technology also can be used to ascertain size and configuration of habitat patches, juxtaposition of habitat patches, and distance between habitat patches. Use of photos and imagery taken over time is an extremely valuable tool that managers can use to inform decision makers and the general public about the impacts of land use changes on wildlife populations. An example where this approach would be useful in Region 2 is monitoring the expansion of oil and gas development within the occupied range of CSTG.

The next level of habitat monitoring is to measure features of the habitat at the local scale, where CSTG occur. Emphasis at this level should be placed on measuring habitat variables of biological importance to CSTG (**Table 18**). An unbiased characterization of the habitat is necessary for these data to be meaningful. This involves measuring habitat attributes at CSTG use sites as well as at random sites using the same techniques. Stratification by land use (grazed or ungrazed), cover type (native or non-native), or density (high, medium, low) of grouse will provide more meaningful information.

Applicable methods for measuring micro-habitat characteristics of cover types used by CSTG are line intercept (Canfield 1941), Daubenmire plots (Daubenmire 1959), and cover poles (Robel et al. 1970, Griffith and Youtie 1988, Benkobi et al. 2000) or variations thereof. Each method is best suited for measuring different habitat characteristics. The line intercept method is most commonly used to measure shrub cover, Daubenmire plots have advantages for measuring herbaceous cover, and cover poles are used to measure vertical cover. The most complete and useful information is obtained when all three methods are used to quantify habitat characteristics. Regardless of the method used, cover values should be recorded by species rather than by categories of species (i.e., grasses, forbs, and shrubs) because some species are of greater value to CSTG than others are. The information can be combined later, if upon further analysis, species composition is not of interest.

Table 18. Habitat variables of potential importance to Columbian sharp-tailed grouse.

Habitat variable	Seasons of primary importance
Distance to mountain shrub and shrubsteppe cover	Winter, spring, fall
Height and density of shrubs	Winter, spring, fall
Shrub patch size and configuration	Winter, spring, fall
Percent forb cover	Spring and summer
Height and density of grasses	Spring and summer
Percent grass cover	Spring and summer
Species richness	Spring and summer
Visual obstruction	Spring and summer
Percent bare ground	Spring and summer
Distance to nearest other cover type	Spring and summer
Percent residual cover	Spring
Snow depth and texture	Winter
Aspect	Winter
Slope	All seasons
Species composition	All seasons

Boisvert (2002) and Collins (2004) measured habitat variables at CSTG use and random sites along transects radiating from the plot center in the four cardinal directions. Line intercept, modified Daubenmire plots, and cover pole readings were taken along each transect. Boisvert (2002) used 20-m transects and Collins (2004) used 10-m transects. Giesen (1997) used cover board (Jones 1968) and point center-quarter (Cottam and Curtis 1956) methods to quantify habitat characteristics at CSTG use and random sites. Oedekoven (1985) conducted vegetation sampling along 100 m transects. Techniques used to measure vegetation included line intercept, point center-quarter using the nearest shrub, quadrat sampling, and a 10-pin point frame. Klott (1987) measured vegetation at brood and random locations along two 20-m intersecting transects with the intercept placed on the flush point of the brood or random point. Shrub cover was measured by recording the shrub species present at 40-cm intervals along each 20-m transect. Cover of herbaceous species was ascertained using Daubenmire plots, and a cover board was used to estimate horizontal screening effects of the vegetation. The multitude of approaches used in these studies conducted in Region 2 indicates that standardized techniques for measuring micro-scale characteristics of habitats used by CSTG are not well established. Standardized and proven techniques are necessary to provide rigorous and consistent data sets to allow for comparisons among areas and years.

Management approaches

Managers must be acutely aware that CSTG populations are affected by multiple factors and that the cumulative effects of these factors must be considered in formulating future management actions. The public's knowledge of this situation should be enhanced. The public needs to be informed about the importance of sagebrush and mountain shrub ecosystems and the threats human activities pose to these ecosystems and their associated wildlife. Most importantly, the public's misconception that sagebrush communities are wastelands of little or no value must be corrected. A concerted educational effort should be directed towards those sectors of the public whose land use practices and activities directly threaten CSTG populations and their habitats. Every effort must be made to involve them in development of management strategies to address threats that their practices and activities have on CSTG. State wildlife agencies should seek help from conservation organizations, such as the North American Grouse Partnership, Audubon Society, National Wildlife Federation, and The Nature Conservancy,

in developing, implementing, and delivering public educational programs to protect CSTG populations and their habitats.

Seasonally, CSTG restrict their activities to relatively small areas, but on an annual basis, the area occupied may be extremely large and involve a mix of ownership and jurisdictions. Thus, successful management will require transcending political and jurisdictional boundaries and must involve cooperation among the different state and federal resource management agencies and between these agencies and private landowners. Management approaches may differ locally and regionally depending on the professional judgment of biologists and the availability of quantitative data from population and habitat monitoring. Whatever strategies are selected, it is imperative that agencies use an adaptive management approach to evaluate the success of implementation (Macnab 1983).

Ironically, some of the same activities responsible for loss and degradation of shrubsteppe and mountain shrub habitats also may be used to enhance and restore these habitats. These activities include fire, grazing, herbicides, and mechanical treatments. Decisions on land treatments using these tools should be based on quantitative knowledge of vegetation conditions over an entire population's seasonal range (i.e., breeding, nesting, brood-rearing, and winter ranges). The treatment selected should be the one that is least disruptive to the vegetation community and has the most rapid recovery time, particularly if the area to be treated is being used by grouse. Selection should not be based solely on economic cost. Treatments should not be undertaken until the limiting vegetation factor(s) has been identified, the treatment is known to provide the desired vegetation response, and land-use activities can be managed after treatment to prevent damage to the treated area.

Giesen and Connelly (1993) described the primary habitat requirements of CSTG and presented guidelines for the management of CSTG populations and their habitats. They acknowledged that because of the lack of experimental data on the effects of habitat alterations on CSTG populations, their recommended guidelines represent hypotheses to be tested and that new information could result in the guidelines being modified. Their specific guidelines include:

- ❖ monitor and maintain records of the location of CSTG lek sites

- ❖ delete from the records any leks that have been inactive for five consecutive years

- ❖ produce maps of all known lek locations and provide these to land management agencies for use in environmental evaluations of proposed management activities

- ❖ avoid vegetation manipulation within the breeding complex (defined as the lek and all land within a 2-km radius)

- ❖ if vegetation manipulation must occur within the breeding complex, defer it until grouse population levels are ascertained and a comprehensive management plan has been formulated for the area

- ❖ monitor the impacts of vegetation manipulation on lek attendance and nesting success for possible mitigation

- ❖ if disturbance (physical, mechanical, or audible) within the breeding complex is unavoidable, it should not occur during the breeding season (March to June)

- ❖ avoid manipulation or alteration of vegetation within the breeding complex during the nesting season (May to June)

- ❖ implement management practices that will not reduce the height, canopy cover, or density of chokecherry, snowberry, sagebrush, serviceberry, or other shrubs locally important for food and cover

- ❖ maintain adequate height-density (mean Robel pole reading = 2.5 dm, Robel et al. 1970) of residual grasses for nesting

- ❖ avoid vegetation manipulation or disturbance that results in the loss of deciduous tree and shrub height, canopy cover, and density within 100 m of streams, including intermittent and seasonally dry secondary drainages

- ❖ manage or eliminate livestock use of riparian areas to minimize destruction of shrubs and trees

- ❖ avoid manipulation or disturbance of vegetation, including herbicide applications,

burning, or mechanical destruction that results in long-term (>5 years) or permanent reduction of height, canopy cover, or density of mountain shrub habitats if shrubs comprise less than 10 percent of the total cover within the area of concern

- ❖ restrict management practices to rejuvenate or increase mountain shrub communities to 25 percent or less of this cover type annually.

Since Giesen and Connelly (1993) published the CSTG management guidelines, numerous other studies have been conducted. Most of these studies provided their own set of recommendations for managing CSTG populations or their habitats based on the data collected. An attempt is made in this assessment to present recommendations using the most current and accurate information available in an effort to complement and update the guidelines by Giesen and Connelly (1993). These recommendations are intended as a guide for resource managers and decision makers to consider when formulating management strategies to address the primary threats identified in this assessment. Actions taken to protect, enhance, or restore particular sites will depend on the characteristics of the particular site and the surrounding landscape. Managers will need to adapt the recommendations presented in this assessment to their particular situation. Managers are encouraged to review the Northwest Colorado Columbian Sharp-tailed Grouse Conservation Plan (Hoffman 2001). This plan contains 248 conservation actions designed to address 23 issues that may affect CSTG in Region 2. Managers also should familiarize themselves with plans that have been developed for CSTG in other states and British Columbia when formulating management strategies for Region 2 (Ritcey 1995, Tirhi 1995, Ulliman et al. 1998, Utah Division of Wildlife Resources 2002).

Managers should be aware of the potential effects on other species of actions taken to benefit CSTG. Where CSTG and sage-grouse occur sympatrically, managers should use extreme caution in treating sagebrush to benefit CSTG. Any loss of sagebrush could be detrimental to sage-grouse and other sagebrush-obligate species, particularly where sagebrush has already been severely depleted or degraded. Managers are encouraged to consult the literature for information on managing sagebrush habitats for species such as greater sage-grouse, Gunnison sage-grouse, sage sparrows (*Amphispiza belli*), sage thrashers (*Oreoscoptes montanus*), and Brewer's sparrow (*Spizella breweri*) before proceeding

with sagebrush treatments to benefit CSTG. Columbian sharp-tailed grouse are not truly a sagebrush obligate, but shrubsteppe communities dominated by sagebrush provide critical breeding, nesting, and brood-rearing habitats for CSTG. Therefore, habitat management strategies for sagebrush-obligate species should benefit or not harm CSTG.

Finally, managers should be aware that far too much emphasis is placed on developing management strategies to protect lek sites without consideration for other seasonal habitat needs. The lek site is only as important as the quality of the surrounding habitat. The consequences to CSTG of having to shift a lek location are probably far less than having to find new areas to nest and raise their broods.

Restoration: Successful management and conservation of CSTG in Region 2 will depend upon preservation and maintenance of healthy sagebrush and mountain shrub communities and implementation of programs to enhance and restore degraded areas. Where possible, restoration efforts should attempt to approximate naturally occurring landscapes. On some areas, restoration may simply require resting the landscape and allowing it to recover naturally. On other areas, the landscape may be so seriously degraded or altered that important plant species are totally absent and a natural seed source is no longer present. Under these conditions, restoration becomes much more difficult and complicated. Natural recovery is neither feasible nor ecologically practical in this situation. For some species, there is no way to rectify their loss because a commercial seed source is not available and procedures for establishment are unknown. If severe degradation has occurred and natural recovery is unlikely, managers must develop restoration programs with the goal of establishing the most ecologically stable community that can exist on the site to protect the soils, maintain the desirable native species that remain, and prevent further degradation. Use of introduced species should not be excluded, but their inclusion requires a greater understanding of their growth form, persistence, effect on native species, and value as food or cover for wildlife. Many severely degraded areas can be substantially improved with proper site preparation, seed selection, and seeding practices, and returned to a condition where they provide suitable habitat for CSTG.

Restoration programs must include strategies for controlling and preventing noxious weeds. Concessions must be made in eliminating or modifying land management practices that contributed to the degradation of the site. Similarly, future uses of the site must be considered and agreed upon before implementing a restoration program. The objectives of the program need to be clearly defined and attainable. Remedial treatments, including management of sites to promote natural recovery, must be carefully planned and directed. Monsen (2005) prepared a comprehensive manual for the restoration of sagebrush and associated shrubland communities. This manual contains information directly applicable to restoration of shrubland communities in Region 2 and should be mandatory reading for all wildlife and land managers within the historic and occupied range of CSTG in Region 2. The manual was specifically prepared to address recovery of sage-grouse habitats, but has direct application to management and restoration of CSTG habitats in Region 2.

Active restoration involves the physical removal of competitive species, preparation of seed beds, and seeding of desired species. A number of species are usually planted, and it is essential to understand the requirements for successful establishment for each species included in the seed mixture (Monsen 2005). Seeds of some species may need to be broadcast while seeds of other species may need to be drilled into the soil at various depths. Lack of attention to all aspects of site preparation and seeding practices could result in widespread failures.

Seeds of many native species were not universally available in the past and little was known about how to plant the seed, and the high cost of native seeds that were available prohibited their use in large restoration projects. This situation has changed in recent years. Private companies and several states have developed their own native seed programs. These efforts have increased the availability and lowered the cost of native seed. In addition, substantial information has been published on seed germination requirements, seedbed preparation, and planting practices for many native species (Monsen 2005).

Administrators of federal and state wildlife and land management agencies should be encouraged to support and fund native seed programs and to develop programs where they do not currently exist. These programs could have positive economic benefits to rural communities. For example, private landowners could be contracted to grow and harvest the seed of locally-adapted plants needed for restoration of native habitats.

Fire: Historically, fire was integral to maintaining CSTG habitats in Region 2. In the absence of natural fires, prescribed fires can be used as a management tool to maintain, enhance, and restore CSTG habitats. Because plant communities respond differently to fire, managers must adhere to burning techniques applicable for the conditions and vegetation types involved (Whisenant 2004). Burn prescriptions for CSTG will differ among grassland, sagebrush, and mountain shrub types. Prescribed fire is the preferred method for treating CSTG habitats because it most closely mimics natural disturbance. However, managers tend to encounter more obstacles to using fire than other methods of treatment. Obtaining burning permits can be difficult where air quality is of concern. Fire cannot be used in many areas because of the potential threat to human life and property. The cost of conducting a prescribed fire has greatly increased due to the liability issues if the fire gets out of control and burns non-target areas. Finally, the public generally has a negative view of fire and does not understand its positive values. This makes it more difficult for managers to promote prescribed fire to their superiors.

Fire is particularly useful in habitats occupied by CSTG for reducing density and competition within mature and over-mature plant communities. Most perennial grasses and forbs within the native cover types occupied by CSTG are moderately resistant to burns. Thus, stands of dense big sagebrush or mountain shrub can be burned to improve the yields and density of grasses and forbs in the understory. Composition, density, and distribution of grasses and forbs must be adequate to achieve the desired response to burning. It is recommended that an inventory be taken of the understory species present within the stand prior to burning. If ground cover is less than 10 percent for grasses and 10 percent for forbs, and only half the expected species of grasses and forbs are present, reseeding should be considered following the burn to promote recovery of the herbaceous community. If annual weeds comprise greater than 10 percent of the ground cover, burning is not advisable as it may accentuate the weed problem. Chemical treatment may be necessary to control weeds followed by burning and reseeding with desirable grasses and forbs.

Shrubs vary in their ability to recover or resprout after fire. The time required for shrubs to re-establish is an important factor to consider when using fire as a management tool. Sagebrush communities recover slowly and have a greater chance of being negatively impacted by fires than mountain shrub communities. The distribution and health of sagebrush-dominated communities within the occupied range of CSTG in Region 2 are less than optimal. Any treatment of the remaining sagebrush must be carefully planned and approached with caution to not cause any further loss or degradation of this important cover type. The primary types of sagebrush within the occupied range of CSTG in Region 2 are mountain big sagebrush (*Artemisia tridentata vaseyana*), Wyoming big sagebrush (*A. t. wyomingensis*), basin big sagebrush (*A. t. tridentata*), and to a lesser extent, silver sagebrush (*A. cana*). With the exception of silver sagebrush, all must recover from fire through seedling establishment (Winward 2004, Monsen 2005). Viable seeds must be incorporated into the soil seed bank and climatic conditions must be highly favorable to insure seedling establishment and development (Winward 2004, Monsen 2005). Depending on the type of sagebrush and size and intensity of the fire, re-establishment may take 20 to 30 years.

Better moisture conditions and greater annual seed production make mountain and basin big sagebrush sites more suited for burning than Wyoming big sagebrush sites (Monsen 2005). However, even on mountain and basin big sagebrush sites, recovery can be unpredictable (Monsen 2005). A conservative plan is the safest and recommended approach to using fire or any other type of treatment (i.e., chemical or mechanical) as a management tool in sagebrush communities. No more than 20 percent of the area should be burned. Several small burns varying in size from 2 to 10 ha in a patchwork pattern is recommended over a single, large burn. Every effort should be made to contain the burn to the area in need of treatment. Not all over-mature or dense (>40 percent canopy cover) stands of sagebrush should be targeted for treatment. Some of these stands should be retained on the landscape as they may provide escape cover for CSTG grouse, especially if the stands occur near (≤ 400 m) lek sites.

Burning should not occur during or following years of drought or during the nesting and brood-rearing seasons. Early spring (early to mid-April) or late fall (late October to late November) burns will produce the best results with the least immediate impacts. Besides disrupting nesting and brood-rearing, late spring, summer, and early fall burns have the potential to destroy seed-bearing plants and leave little seed in the soil seed bank. If summer or fall burning is the only option, seed bed preparation and reseeding should occur following the burn. Any reseeding should be done in the fall. Where possible, pockets of live sagebrush plants and native grasses and forbs should be maintained as a seed source within the perimeter of the

burn. Burns on broad ridgelines, mesas, benches, and flats will benefit CSTG more than burns along narrow drainages or on steep (>20 percent) slopes. Additional treatments should be deferred until the initially treated area again provides suitable habitat for CSTG. Treated areas should be rested from grazing for at least three years and preferably five years to allow for seedling establishment and development. Subsequent grazing should be light to moderate.

Burning to eradicate sagebrush or mountain shrub communities to improve grass production for livestock should be discouraged. Range fires that threaten to destroy large (>100 ha) areas of sagebrush should be suppressed because of the long time period required for sagebrush to become reestablished and the uncertainty that it will re-establish. The possible exception is when wildfires start where extensive conifer invasion has occurred within the sagebrush type. Seeding with the appropriate subspecies of sagebrush is recommended during the first fall following the fire to promote re-establishment of sagebrush.

Mountain shrub communities are more resilient to burning than sagebrush. The most prevalent and dominant shrub species within the mountain shrub community in Region 2 are Gambel's oak and serviceberry. These species may grow in association with chokecherry, mountain snowberry, and big sagebrush, or they may form separate, dense thickets to the exclusion of the other species. With the exception of big sagebrush, most shrub species in the mountain shrub community are fire tolerant and resprout after fire (Monsen 2005). This allows for shorter recovery time and precludes the need for reseeding or dependence on a natural seed source for re-establishment.

Burning should only occur in over-mature or dense mountain shrub stands that are considered unsuitable for CSTG. Due to the shorter recovery time, larger burns (20 to 100 ha) are acceptable within the mountain shrub type. No more than 30 percent of the stand should be burned at one time. Subsequent burns can be conducted at five to 10 year intervals as needed. Where mountain shrub communities comprise less than 15 percent of the landscape, a more conservative approach to burning is recommended. Individual burns should be smaller (2 to 10 ha), burn intervals should be longer (10 to 15 years), and no more than 10 percent of the area should be burned at one time.

Where fire has been absent or suppressed for long periods within the mountain shrub type, large contiguous patches of Gambel's oak dominate the landscape. Columbian sharp-tailed grouse avoid these areas, except where the patches border more open cover types. Repeated burning of oakbrush stands at approximately five to 10-year intervals can improve their value as habitat for CSTG by reducing the prevalence of oakbrush and allowing other shrub species (i.e., serviceberry and chokecherry) of greater importance to CSTG to become established. Repeated burning also can be used to create and maintain herbaceous openings within the mountain shrub community that may provide late summer and fall habitats for CSTG and snow roosting sites in winter. Stands dominated by desirable species, including serviceberry and chokecherry, also may become too dense and over-mature and require burning to improve their suitability for CSTG.

The greater resiliency of mountain shrub species to fire provides managers with more options for dealing with wildfires. Managers should consider adopting a "let burn" policy for wildfires within the mountain shrub zone where there is no threat to human life or property, mountain shrub communities comprise greater than 25 percent of the landscape, and the area where the fire has started is in need of disturbance (i.e., the stands are too dense, over-mature, or dominated by oakbrush). Fire management plans prepared by the BLM, USFS, and counties should be reviewed, and where appropriate, advice should be provided on ways to modify the plans to benefit CSTG.

Chemical and mechanical treatments: Chemical and mechanical treatments can be used to manipulate shrub density when prescribed fire is not feasible or where the treatment must be precisely applied to prevent damage to adjacent areas. Mechanical and chemical treatments each have their advantages and disadvantages (Stevens and Monsen 2004, Vallentine 2004, Monsen 2005). The primary drawback of chemical treatments is their effect on non-target, desirable plant species, particularly forbs, but also shrubs. Another negative effect is the reduction in insect populations that use forbs and shrubs that are killed by the herbicide. For these reasons, widespread aerial or ground application of herbicides that also harm non-target forbs and shrubs is discouraged, except when such treatments are necessary to control invasive plant species. Whenever possible, herbicides should be applied with ground equipment so that only areas supporting invasive species are treated. This will minimize the damage to non-target species. Non-specific herbicides should only be used on localized areas where their application can be carefully controlled.

There are herbicides on the market that target specific plant species (Vallentine 2004). These herbicides applied at low rates can be used to selectively control but not totally eliminate target plants in an area. One herbicide that has been used to thin big sagebrush stands and simultaneously stimulate grass and forb production is tebuthiuron (Crawford et al. 2004). Tebuthiuron and other similar-acting herbicides offer obvious advantages over broad-acting, non-specific herbicides. Their use as a tool for managing CSTG habitats should be considered.

Applications of restricted use pesticides must follow the "directions for use" section on the product label, and the applicator must be certified by the state. It is a violation of federal law to apply restricted use pesticides in a manner that is inconsistent with the labeling. Vallentine (2004) and Monsen (2005) provide a complete discussion of the different types of equipment that can be used for chemical control of plants. First and foremost, the method of application should be based on safety and precision of application. Herbicides undergo extensive toxicological, environmental, and plant efficacy testing. Applicators should consult this database of knowledge to select the safest herbicides to use for each weed and brush control program.

Many types and variations of mechanical treatments can be used to remove undesirable trees, shrubs, and weeds and to prepare the soil for natural revegetation or for reseeding, including chains, plows, harrows, choppers, mowers, shredders, aerators, and disks (Stevens and Monsen 2004, Monsen 2005). Mechanical treatments may damage or kill non-target plants, but depending on the type of mechanical treatment, the effects on non-target plants are usually less than may occur from fire and non-specific chemical treatments. Mechanical treatments are easier to control the size and shape of the treatment, amount of brush removed, and timing of the treatment. Mechanical treatments are less effective in controlling sprouting shrubs, may increase the risk of erosion, tend to have a shorter treatment life than fire or chemical treatments, and may have limited use on steep, rocky, or inaccessible terrain.

McArdle (1977) found that CSTG in the Curlew Valley of Idaho responded favorably to chaining, burning, and spraying, but chaining appeared to provide the most benefit. Chaining had more of an immediate, positive effect on the overall cover. This resulted in CSTG increasing use of the chained areas more rapidly than in areas that were sprayed or burned. McArdle (1977) recommended that manipulations should be done in an irregular pattern with not less than 30 and no more than 45 m between the sides of the pattern to maximize the "edge effect" of the treatment.

Grazing: No single grazing strategy is appropriate for all grassland or shrubland habitats occupied by CSTG. Grazing management must be tailored to the condition and potential of each grazing unit (Holechek et al. 2001). This includes recognizing where and under what conditions grazing is not an ecologically appropriate practice. Sound grazing management must include strategies to protect the plant resource and promote ecological stability (Holechek et al. 2001). Public land managers and livestock producers should use the relative abundance of key wildlife species as an indicator of range condition. If species such as sage-grouse and sharp-tailed grouse are absent or occur in low numbers, this is a strong indication the range is in suboptimal condition. Part of good range stewardship is being aware of and providing for the needs of wildlife. Wildlife professionals and livestock producers must become more tolerant, understanding, and respectful of each other's perspectives and focus on areas of mutual interest.

The ultimate goal should be to provide for a level of grazing that at least maintains and ideally improves the long-term stability of CSTG populations and their habitats in Region 2. This is a realistic goal considering there are already areas in Region 2 where healthy grouse populations occur on lands that are grazed by domestic and wild ungulates. Ironically, some of the most abused and overgrazed ranges within Region 2 occur on public lands administered by the USFS, BLM, and State Land Board. This is partially due to past grazing management practices, but it is compounded by current grazing patterns. Stocking rates have declined considerably on public lands, but agencies responsible for their management have not rested the lands and allowed them to recover from past over-use. Without rest, there has been no opportunity for recovery. This explains in part why public lands account for about 32 percent of the occupied range of CSTG in Region 2 but support less than 15 percent of the known active leks.

Public land managers must set the example on how to manage rangelands properly for long-term ecological stability. The following guidelines for managing livestock grazing on public lands are adapted and modified from The Wildlife Society's final position statement on livestock grazing on federal rangelands in the western United States (www.http://wildlife.org, accessed 5 November 2006). Many of the guidelines are applicable to private lands and should be encouraged by

county extension agents and other government officials that work directly with the private sector. Livestock grazing on public lands should:

1. reflect the standard upon which other lands are managed and clearly demonstrate how wildlife and livestock management are compatible

2. be based on rigorous scientific studies

3. consider all rangeland resources, trends, interactions, and human values

4. provide for adaptive management as new knowledge and understanding of rangeland ecosystems becomes available

5. include provisions, funding, and criteria for monitoring

6. allow for flexibility and adaptability to changing habitat and environmental conditions, such as drought

7. involve effective coordination and cooperation among agencies and affected publics

8. allocate ample resources to enforce regulations and to levy strong penalties when regulations are violated

9. promote heterogeneous landscapes comprised of diverse mosaics of plant communities

10. meet conservation objective for threatened, endangered, and sensitive wildlife and plant species

11. promote use of native species for restoration

12. manipulate vegetation by burning, spraying, or mechanical treatment only when necessary to maintain, improve, or restore the health of the plant community

13. avoid projects designed to manipulate vegetation for the sole purpose of increasing forage production for livestock

14. develop and implement objective and quantifiable criteria for designating lands unsuitable for livestock grazing

15. implement strong public education programs that clearly articulate goals and desired outcomes of livestock management

16. allow for effective citizen participation in developing grazing policy alternatives, implementing policy provisions, and evaluating policy outcomes.

Regardless of the grazing management plan that is decided upon, it should adhere to certain grazing principles that are known to maintain healthy rangelands (Montana Watershed Coordination Council's Grazing Practices Work Group 1999). Most plants are generally healthier when properly used but not overgrazed. However, the effects of grazing cannot be judged by averaging use on all plant species. Some species are more preferred than others are. That some species are lightly grazed or not grazed at all does not compensate for other species being heavily grazed. It is important to identify the key species that will serve as indicators of grazing intensity. Key species are the species that livestock are most likely to use the heaviest and will be the first to show signs of over-use. If key species are not overgrazed, it is reasonably safe to assume the other species will not be either. The same concept applies to range condition within the grazing unit. If parts of the grazing unit are untouched or only lightly grazed, while other sections are continually and heavily grazed, averaging the two extremes will not provide an accurate picture of overall condition. If an uneven distribution of grazing is noted, then animal distribution may need to be improved through herding, salting in unused areas, or developing additional water sources.

No grazing unit should be grazed for more than half the growing season of key species. Timing of grazing must allow for growth and regrowth of the key plant species. Periods of use throughout the growing season should be alternated from year to year. At least once every three to four years, the grazing unit should be rested. Grazed pastures should not be over-used to compensate for rested pastures, nor should rested pastures be over-utilized after they are rested (i.e., a year of rest does not compensate for a year of excessive use). If continual seasonal grazing (an area is grazed at the same time every year due to access problems, short growing season, or both) is the only alternative, the stocking rate should be based on achieving light (<30 percent utilization) use of the key species. Under rest rotational grazing, the rested unit should not be grazed until after (mid-July) the nesting season the following year and then at light intensity. Under deferred rotational grazing, a unit should be grazed only once

within the year at light intensity and should be grazed at a different time the following year. Deciding when it is time to move livestock should not rely on calendar dates. Instead, precipitation, plant growth, and target grazing use level should be used to decide when to move livestock to another grazing unit. Whenever the level of use exceeds 50 percent or the forb component of the plant community falls below 15 percent, then a 2-year rest period is recommended to allow for recovery.

One of the critical factors assuring that grazing does not negatively impact grouse habitats is setting a target level of use for key species that will leave adequate cover and food after the grazing animals are removed. The target level required to leave adequate cover for CSTG will generally be lower than what the key plant species can sustain without prolonged damage. For instance, a key species may be able to sustain 40 percent use without any prolonged damage to the plant, but this level of use may not leave enough cover or food for grouse. Therefore, the compatible level of utilization may be 20 to 30 percent. The compatible level of use may change annually and from one site to the next. Under good growing conditions, the compatible level of use will be greater. In drought years, it will be lower. What really matters is not how much vegetation is removed, but how much vegetation is left.

The problem with utilization measurements is that they are difficult to interpret and compare from one year to the next. Yearly vegetation growth on western ranges fluctuates greatly in response to precipitation. Twenty-five percent use in a wet year will have less impact on remaining cover after the grazing season than 25 percent use during a drought year (i.e., the same level of use can equate to different stubble heights remaining after grazing). Hoffman (2001) reported that additional data besides utilization are needed to monitor grazing effectively to insure that areas meet habitat objectives for CSTG. Holechek et al. (1982) recommended that measuring stubble height rather than use would provide a more meaningful and practical measure of evaluating grazing intensity from the standpoint of wildlife. Unlike use, stubble height is easily measured, easily interpreted, and provides a common reference point for decision making regarding grazing levels.

Ulliman et al. (1998) recommended that residual herbaceous cover height in CSTG habitats should be 20 cm or greater based on Robel Pole visual obstruction readings (Robel et al. 1970) at the end of the grazing season. The Habitat Suitability Index Model developed for CSTG indicates optimum nest/brood habitat occurs where Robel Pole readings exceed 25 cm (Meints et al.

1992). Cover pole readings at nest and brood sites in Colorado averaged 37 and 50 cm, respectively (Boisvert 2002). Equating these values to standard use classes for key western range grasses (Holechek et al. 2001), only light use ($\leq$ 30 percent) by livestock appears to be compatible with CSTG use on most range types.

Restored and rehabilitated sites should not be grazed until at least the end of the second growing season following treatment or seeding (reviewed by Stevens 2004). The minimum period of rest from grazing for treated sites will vary with:

❖ vegetation type treated

❖ climatic conditions immediately preceding, during, and following treatment

❖ shrub, forb, and grass species seeded

❖ seedbed preparation and seeding techniques used

❖ severity of competing weedy species.

Seeded species must be given the opportunity to establish substantial root systems, to accumulate carbohydrate reserves, and in the case of some grasses and forbs, to produce a seed crop. Shrubs tend to establish more slowly than forbs and grasses do. When shrubs are included in the seed mixture, five to six years of non-use may be required to provide for maximum establishment and development. When grazing is permitted, it should be lighter than would normally be allowed within a fully mature community. Spring and early summer grazing can be damaging to newly established plants and should be avoided. Temporary electric fences or implementation of special hunting seasons may be necessary to minimize excessive use of treated sites by wild ungulates.

Management of CRP: Several studies have suggested that some CRP fields may provide little or no benefit to CSTG and may in fact contribute to higher predation rates and lower nesting success due to lack of structural and vegetation diversity (Sirotnak et al. 1991, McDonald 1998, Boisvert 2002). Seed mixtures in CRP should include a minimum of four grass, three forb, and one shrub species in the following approximate proportions: 70 to 75 percent grasses, 15 to 20 percent forbs, and 5 to 10 percent shrubs (**Table 19**). Bunchgrasses should be favored over sod-forming grasses, and legumes should be favored over other types of forbs. The recommended shrub species for most CRP

Table 19. Recommended plantings for Conservation Reserve Program lands within the occupied and potential range of Columbian sharp-tailed grouse in USDA Forest Service Rocky Mountain Region.

Category[1] and scientific name	Common name	Status
Primary grasses		
Pascopyrum smithii	Western wheatgrass	Native
Elymus trachycaulus	Slender wheatgrass	Native
Bromus marginatus	Mountain brome	Native
Leymus cinereus	Basin wildrye	Native
Secondary grasses		
Festuca idahoensis	Idaho fescue	Native
Poa secunda	Sandberg bluegrass	Native
P. fendleriana	Muttongrass	Native
Pseudoroegneria spicata	Bluebunch wheatgrass	Native
Achnatherum hymenoides	Indian ricegrass	Native
Primary forbs		
Hedysarum boreale	Utah sweetvetch	Native
Medicago sativa	Alfalfa	Introduced
Vicia americana	American vetch	Native
Sanguisorba minor	Small burnet	Introduced
Secondary forbs		
Balsamorhiza sagittata	Arrowleaf balsamroot	Native
Eriogonum umbellatum	Sulphur-flower buckwheat	Native
Linum perenne	Blue flax	Native
Penstemon strictus	Rocky Mountain penstemon	Native
Symphyotrichum chilensis	Pacific aster	Native
Tragopogon dubius	Yellow salisfy	Introduced
Astragalus cicer	Cicer milkvetch	Introduced
Onobrychis viciaefolia	Sainfoin	Introduced
Crepis acuminata	Tapertip hawksbeard	Native
Primary shrubs		
Artemisia tridentata	Big sagebrush	Native
Secondary shrubs		
Ericameria nauseosa	Rubber rabbitbrush	Native

[1]Primary grasses should comprise approximately 50 percent of the seed mixture, secondary grasses 20 percent, primary forbs 15 percent, secondary forbs 5 percent, primary shrubs 8 percent, and secondary shrubs 2 percent.

plantings within the range of CSTG is big sagebrush. It is important to plant the correct subspecies of big sagebrush based on local conditions (Winward 2004, Monsen 2005).

Appropriate introduced species, such as alfalfa, are acceptable and can be especially valuable where they provide an ecological substitute for structurally important but commercially unavailable native species (Rodgers and Hoffman 2005). Aggressive species that may crowd out other components of the mixture should be avoided, as should weak-stemmed species that flatten easily under heavy snows. Site-adapted seed should be planted over other seed sources when available. This is highly recommended for sagebrush plantings (Monsen 2005).

The potential height of the mature stand should be considered in selecting seed mixtures. Seed mixtures that produce stands that range from 30 to 75 cm in height at maturity are recommended. The height of the vegetation should vary across the stand. This can

be accomplished by planting different seed mixtures in different parts of the field. This recommendation also applies to shrub plantings. Sagebrush seed should be planted in selected areas, including draws, north slopes, and benches where snow may accumulate and protect the young plants from browsing by wild ungulates. All types of sagebrush establish better by broadcast seeding. Seeds should not be placed more than 0.63 cm deep, and the soil surface should be compacted or made firm by harrowing, chaining, or compact rolling (Monsen 2005). It is best to reduce the seeding rate of grasses and forbs or not to plant them at all where sagebrush seed is distributed. This will reduce competition and increase the chances of the sagebrush seed germinating and becoming established. Grasses and forbs from adjacent areas should eventually fill in beneath the sagebrush.

Without periodic disturbance, CRP stands in Region 2 may become less vigorous, forb abundance may decline, and excess litter may accumulate. Each of these outcomes will diminish the suitability of the stand for CSTG. Therefore, stand management (i.e., burning, grazing, haying, interseeding, and disking) may be necessary, but management should only be implemented when it is consistent with the wildlife, water quality, and conservation objectives of CRP. In Region 2, most CRP stands should only require disturbance once every 10 years. Burning and haying may damage or kill sagebrush. Thus, neither activity is recommended as a means of disturbance where sagebrush is established in the stand, unless the sagebrush occurs in patches and can be avoided when burning or haying. This is one reason why sagebrush seed should be planted in patches rather than uniformly distributed across the field. Haying should not occur until the stand is firmly established. This may require three to five years. Haying of CRP lands within the occupied range of CSTG in Region 2 should not occur between 20 March and 1 August, which coincides with the breeding, nesting, and primary brood-rearing periods. No more than 50 percent of a stand should be hayed at one time, and different portions of the field should be hayed each time. At least five years should occur between haying events.

Grazing of most CRP fields within the occupied range of CSTG in Region 2 is generally not an option due to the lack of water and fencing. Development of water sources and construction of new, permanent fences in CRP fields should be discouraged. Instead, landowners wanting to graze CRP fields should consider hauling water and using temporary electric fencing where possible. Only light to moderate (25 to 40 percent utilization) grazing should be allowed. No grazing should occur before 15 July, and livestock should be removed by 15 September. At least five years should occur between grazing events. Grazing should not be allowed in addition to haying. When grazing CRP, there is the potential for livestock to move into adjacent native cover types. The livestock may actually prefer the native cover over the CRP stand, especially if the stand is dominated by sod-bound, decadent grasses. This may result in overgrazing of the native cover and failure to achieve the desired disturbance within the CRP stand. Salting, placement of water sources, and temporary electric fencing can be used to address this problem. If cattle cannot be excluded from native habitats when attempting to graze CRP stands, then grazing should not be permitted.

Managed haying and grazing should not be at the discretion of the landowner. Approval to conduct managed haying or grazing should be based on whether the field needs management to enhance the diversity and vigor of the stand. In many cases, it may not be necessary to hay or graze a field at all over the course of a 10-year contract. Heavy, periodic use by wild ungulates may be enough to maintain the vigor and diversity of the stand.

Emergency haying or grazing may be authorized anytime at the state or national level to provide relief to livestock producers in areas affected by severe drought or other natural disasters. Emergency haying and grazing generally have negative implications to wildlife because food and cover are removed when they are already in short supply due to poor growing conditions (i.e., drought). Under no circumstances should landowners be allowed to hay or graze more than 50 percent of the field under the emergency provision. If emergency haying or grazing must be applied, such events should count as part of the managed haying and grazing cycle and should not become additive to managed haying or grazing events.

Haying and grazing tend to remove excess litter. Since excess litter removal is essential for successful interseeding of legumes in CRP, Rodgers and Hoffman (2005) suggested that emergency and managed haying or grazing could provide an opportunity to enhance CRP stands lacking vegetation diversity. Stand improvement could be encouraged by forgiving the 10 or 25 percent payment reduction to the landowner for emergency and managed grazing or haying, respectively, if in return the landowner enhances the affected area.

In October 2004, the National Wildlife Federation and several of its state affiliates filed a lawsuit in the U.S. District Court for the Western District of Washington

challenging certain provisions of managed haying and grazing on CRP lands. Specifically, the lawsuit challenged the frequency allowed for managed haying and grazing on CRP acreage and the dates set to define the primary nesting and brood-rearing seasons when haying and grazing are prohibited. A settlement was reached in September 2006 (http//:www.fsa.usda.gov/ Internet/FSA_file/353646-pdf, accessed 9 May 2007). The settlement is limited to certain states and applies to new contracts, including re-enrollments in those states approved after 25 September 2006. The settlement also applies to contract extensions in those states approved after 25 September 2006 if the participant had not previously been approved under the CRP contract for managed haying and grazing. The settlement does not pertain to emergency haying and grazing. Terms of the settlement that apply to CSTG range in Region 2 are as follows:

❖ The frequency of managed haying is limited to no more than once every 10 years

❖ Only 50 percent of the field can be hayed at one time, with the other 50 percent not eligible for haying for at least five years. For example, if 50 percent of the field is hayed in year 3, the other 50 percent cannot be hayed until year 8. The landowner is not required to hay 50 percent each time. However, once they have hayed 50 percent of the field, they must wait five years to hay the other 50 percent. For example, if they hay 25 percent in year 3 and another 25 percent in year 4, the remaining 50 percent is not eligible for haying until year 9

❖ Managed grazing is limited to no more than once every five years. Landowners may graze 100 percent of the field at no more than 75 percent of the Natural Resource Conservation Service determined stocking rate

❖ Managed haying and grazing are not allowed from 15 March to 15 July during each calendar year

❖ Managed haying and grazing may not begin until the cover is fully established.

The new rules are an improvement over the old rules, which allowed managed haying and grazing every three years, provided the field was not hayed or grazed under the emergency provision during the previous two years. However, a major problem with the old rules was not addressed. Under the new rules, managed haying or grazing is still allowed regardless of whether the field is in need of management. The only requirement is that the cover must be fully established. Fields that are fully established may provide ideal habitat for CSTG for several years before their suitability starts to decline. Prematurely haying or grazing these fields may diminish their suitability for CSTG.

A greater proportion of CRP lands surrounded by large blocks of agricultural lands should be shifted to localities near native cover types. These new CRP blocks will complement existing native habitats by creating habitat mosaics that will benefit CSTG far more than isolated blocks of CRP. This goal could be accomplished through modification of the Environmental Benefits Index.

Ecologically appropriate CRP stand enhancement should be required for future re-enrollment of stands in poor condition. This may involve complete elimination of stands comprised almost entirely of aggressive, non-native grasses, such as smooth brome. Monsen (2005) describes the steps necessary to accomplish this task successfully.

National Priority Areas are regions of the country designated by the FSA as having severe adverse water quality or habitat issues. Columbian sharp-tailed grouse currently occupy less than 10 percent of their former range due to the loss and degradation of shrubsteppe, mountain shrub, and riparian shrub cover types in the western United States. Within the same general area, the loss and degradation of sagebrush types have resulted in greater and Gunnison sage-grouse disappearing from approximately 50 and 90 percent of their former ranges. This clearly is a severe habitat issue and should be justification for establishing a National Conservation Priority Area within the sagebrush and mountain shrub rangelands in the western United States.

Farm Service Agency leaders and congressional representatives should be informed about the importance of CRP to wildlife in the West and the potential consequences if the program is discontinued or if priorities are shifted to other areas. Agencies responsible for administration of the program must be allocated adequate funds to insure that participants are in compliance with conditions of their contracts and, where necessary, to levy penalties when the rules are violated. County committees, county commissioners, producers, and agricultural businesses should be encouraged to support and approve waivers to increase the allowable CRP acreage within their counties. Funding sources

should be established to assist landowners willing to plant seed mixtures that benefit wildlife. It is critically important that state and federal wildlife agencies and conservation organizations work closely with the FSA to optimize the conservation benefits of CRP for wildlife. Towards this end, wildlife agencies and conservation organizations should provide whatever assistance the FSA needs to develop, implement, and expand new CRP practices that benefit wildlife, such as the State Acres for Wildlife Enhancement (SAFE) initiative. This initiative further extends the conservation benefits of CRP by directly addressing the needs of endangered, threatened, and other high-priority wildlife species. Every effort should be made to maximize the acreage enrolled in this program within the occupied range of CSTG in Region 2.

Oil and gas development: It is imperative that a law similar to the Surface Mining Control and Reclamation Act be developed and passed to regulate oil and gas development on federal and state lands. This law should apply to any lands where the federal government or states own the mineral rights. It should include criteria for identifying areas that should be off-limits to oil and gas development. It also should provide for a level of bonding to insure that appropriate reclamation is completed. The law should set forth minimum uniform requirements for all oil and gas activities to minimize disturbances and adverse impacts on fish, wildlife, and related environmental values, with restoration of land and water resources as the number one priority. A separate entity outside the oil and gas commission should be established within state governments whose primary responsibility is to enforce the law and to regulate the oil and gas industry.

The following recommendations are based on principles developed by a working group of the Theodore Roosevelt Conservation Partnership. Participants on the working group included representatives from the American Sportfishing Association, Association of Fish and Wildlife Agencies, Izaak Walton League of America, North American Grouse Partnership, Rocky Mountain Elk Foundation, Wildlife Management Institute, and The Wildlife Society. The recommendations are intended as a guide for dealing with energy development on public lands in the West.

❖ The administration and Congress should pass legislation to establish a new, long-term, dedicated funding source to adequately provide BLM, USFS, and state fish and wildlife agencies the necessary means to

monitor, evaluate, and protect habitats and wildlife populations affected by oil and gas development.

❖ Funding appropriated for fish and wildlife management should be used to manage habitats and populations proactively. Much of the funding the BLM receives for fish and wildlife biological services is being directed to processing permits for expanded energy development.

❖ Annual or short-term increases in federal funding for energy development should be matched by funding to monitor and mitigate the consequences to the environment.

❖ A specific "conservation strategy" for each energy field or project that would go beyond the National Environmental Policy Act (NEPA)-level evaluations and plans currently being conducted should be used to proactively address wildlife needs. The conservation strategy should be finalized before development starts and must provide specific recommendations and actions to minimize impacts, while establishing plans for mitigation, restoration, monitoring, and adaptive management.

❖ Managers, industry, and other decision makers must be held accountable and responsible for following laws, regulations, and policy including commitments made in NEPA documents. A process for accountability that allows the public to track compliance with law, policy, plans, and commitments made in decision documents should be established.

❖ Compliance with, and enforcement of, requirements from Records of Decision should be included in the written performance standards for federal employees responsible for each phase of the energy development process.

❖ Operational compliance and performance should be linked to lease rights. Thus, if operators do not comply with the provisions/stipulations of their operating permit, they would be in violation of the lease, and cessation of drilling activities would be warranted.

❖ Mineral leasing should be done in a manner that takes into account the future impacts from development on wildlife resources. This requires a change in the current leasing process that would provide for a prior assessment of impacts from lease development before leasing occurs.

❖ Public involvement from all stakeholders should be assured.

❖ Federal officials must use adaptive management based on the best available information and coordinate with state agencies. An effective adaptive management process must include regular reviews of both state and federal findings from research and monitoring, active consideration of alternative energy field management, and the means for making management changes for future development where needed to lessen impacts to wildlife.

❖ A clear, open federal planning process and decision-making process that follows administrative law is essential.

❖ Leasing and development should be guided by complete and current land use plans developed with public review, based on current information on how development is likely to proceed.

❖ Federal land managers must make decisions on energy development following processes that allow for adequate public review. Sufficient information about proposed energy leases and development must be provided to the public to allow for understanding and reasonable comments. The time for public comment must be commensurate with the complexity of the proposal.

❖ Meetings related to energy development on public lands should be part of the public record.

❖ The energy development planning process should include science-based mitigation and an adaptive management process that uses the most rigorous data available to adjust development. Off-site mitigation is essential when on-site mitigation cannot be effectively used or is inappropriate to offset resource values impacted at the project location.

❖ Off-site mitigation that only involves improving existing habitats outside the impacted area should not be acceptable. Off-site mitigation should be equal to the area rendered unsuitable due to oil and gas activity. For instance, if 200 ha of occupied habitat are rendered unsuitable for CSTG, the appropriate mitigation should be to create or restore 200 ha of habitat somewhere else, preferably within 2 km of the impacted site. The success of the mitigation should be measured based on whether the newly created habitat is used by CSTG. Off-site mitigation should be in addition to reclamation requirements on the impacted site.

❖ There are certain special and unique places that should be entirely off-limits or extremely limited to oil and gas development.

The Wyoming Game and Fish Department (2004) has prepared a working document to assist managers in dealing with oil and gas issues (available at http://gf.state.wy.us/wildlife/index.asp, accessed 6 December 2006). This document includes a comprehensive list of standard management practices and mitigation options to reduce the impacts associated with oil and gas development. Information contained in the document is directly applicable to Region 2. The Wyoming document is adapted from a BLM publication entitled "Best Management Practices for Oil and Gas Development on Public Lands" (available at http//:blm.gov/bmp/, accessed 6 December 2006). However, the Wyoming document contains more specific criteria and better defines the circumstances and extent to which the management practices and mitigation options should be applied to protect wildlife resources and habitat functions. As a working document, the recommendations are updated and revised as relevant new information becomes available.

Loss of habitat: Protecting 100 percent of the remaining habitats occupied by CSTG in Region 2 is desirable, but unrealistic due to the preponderance of habitat occurring on private lands. Maintaining, improving, and possibly creating new habitats on public lands should be pursued to compensate for loss of habitats on private lands. With proper management, potentially suitable habitats on BLM and USFS lands in

southwestern Colorado, west-central Colorado, north-central Colorado, and southwestern Wyoming could support viable populations of CSTG. Public lands should receive the highest priority for protection, enhancement, and restoration of native plant communities.

A certain level of habitat loss within the occupied range of CSTG in Region 2 can occur without adversely affecting the stability of the population. However, proper planning and cooperation among all parties involved are critical. County planners and county commissioners should be informed about the status, distribution, and habitat requirements of CSTG so they can make sound decisions regarding development proposals and request appropriate mitigation measures. County planners and commissioners should be encouraged to develop a consistent process of sending development proposals to local state wildlife agency representatives for comment. In turn, state wildlife agencies should provide the counties with the most recent and accurate information on location of leks and other critical habitats, and identify areas where new construction could potentially fragment populations. Wildlife agencies should work with planners and county commissioners on development and modification of land use and zoning plans to protect critical CSTG habitats. Agency representatives should be present at county commission and planning meetings to provide testimony and offer suggestions to avoid, minimize, correct, or mitigate impacts of development on CSTG. State wildlife agencies and county governments should offer incentives to developers who protect and enhance CSTG habitats. Cluster development, density credits, development right transfers, land exchanges, open space, conservation easements, and fee title acquisition should all be considered as mechanisms to minimize or prevent loss of CSTG habitats. This must be done in a manner that balances the need to conserve habitats for CSTG with the rights of private property owners to develop their land.

Utility companies also should be provided with the most recent information on location of leks and other critical CSTG habitats, and they should be encouraged to place lines underground. Abandoned utility lines should be removed, and construction of new utility lines should be done within existing corridors or along roads whenever possible. Overhead utility lines near leks and other critical CSTG habitats should be appropriately marked to minimize collisions and fitted with devices to deter perching by raptors.

Construction of new roads should avoid CSTG habitats where possible or at the very least avoid direct line of sight between known leks and road traffic. Speed limits should be set to reduce vehicle collisions with grouse and other wildlife. Managers should consider options such as seasonal use restrictions, closure, removal, or realignment of non-essential roads on public lands that occur near leks or traverse nesting, brood-rearing, or winter habitats. Any roads constructed across public lands for the sole purpose of oil, gas, or coal exploration and extraction should be removed and the roadway seeded with native vegetation after the activity is completed.

Hunting: State wildlife agencies should not knowingly allow overharvest of CSTG on public lands under the pretense that these lands are repopulated by grouse from surrounding private lands that are unhunted or lightly hunted. This rationale portrays a poor image to the non-hunting public and discourages other user groups from changing their practices to benefit CSTG. It also may not be a biologically sound rationale for CSTG, where the overall range has been drastically reduced and remaining habitats face multiple threats of further loss and degradation. Hunting of CSTG in northwestern Colorado is an acceptable use of the resource, but solutions must be sought to reduce hunting pressure and harvest on public lands. Possibilities include leasing more State School Lands for public hunting, implementing a permit system to limit hunter participation, setting shorter seasons that open later in the fall, setting the possession limit equivalent to the bag limit (i.e., possession and bag limit = 2 grouse per hunter per season), and changing the legal time hunting can begin in the morning to 0900 to discourage hunters from shooting birds on or near leks.

Hunting of transplanted populations should only be considered when lek counts indicate a minimum of 200 males in the population. Hunting should only be allowed on a limited permit basis designed to remove no more than 10 percent of the estimated fall population. More liberal seasons can be approved as populations increase and expand their range.

State wildlife agencies should explore new ways to increase the precision of harvest surveys for grouse. The biggest problem is identifying the sampling universe (i.e., those small game license buyers that actually hunt grouse). One recommended solution to this problem is to issue a separate license for grouse hunting. This recommendation has not received wide support from agency administrators. The Hunter Information Program (HIP) attempts to identify the sampling universe for some game birds, including CSTG, by asking hunters to indicate what game birds

they are likely to hunt when they register with the program. The reliability of this approach in identifying CSTG hunters has not been tested, and only a portion of the hunters that indicate they plan to hunt CSTG are sampled. Until a more reliable means of identifying CSTG hunters is available, 100 percent of the hunters registering with the HIP that say they are very likely to hunt CSTG should be sampled.

Captive-rearing: Captive-rearing of grouse for release into the wild has not proven to be a successful management tool and should only be considered as a last resort to prevent extinction (Storch 2000). Grouse are difficult to breed and raise in captivity because of their complex behaviors, special requirements, and vulnerability to diseases and parasites when placed in captive situations (Johnsgard 1973). Captive-rearing is labor-intensive and costly, but most importantly, grouse raised in captivity rarely survive and reproduce when released into the wild (Storch 2000). In Germany, four release projects for black grouse and nine for capercaillie involving several thousand birds failed to establish a single self-sustaining population (Klaus and Bergmann 1994, Klaus 1997). Efforts to raise sharp-tailed grouse in captivity for release into the wild were abandoned in Michigan due to difficulties in raising birds to maturity (Ammann 1957). Although Attwater's prairie chickens are currently being successfully bred and raised in captivity, their survival in the wild has been extremely low (Lockwood 1998, Silvy et al. 1999). Continued supplementation has been necessary, with no indication that the captive-bred birds are capable of establishing a self-sustaining wild population. With the exception of the Attwater's prairie-chicken, release of captive-reared birds should not be a conservation priority for any grouse species in North America. In most cases, when it becomes necessary to resort to captive breeding, it is because suitable habitats of sufficient size and suitability are no longer available to support a self-sustaining wild population. At this point, release of captive reared birds has little or no chances of success. According to the International Union for Conservation of Nature and Natural Resources (1987) policy statement on captive breeding, the establishment of captive populations as a long-term conservation strategy to reduce the risk of extinction is only recommended when a taxon has declined to less than 1,000 individuals in the wild. Columbian sharp-tailed grouse are in no immediate danger of reaching this critically low level. Adequate numbers remain in British Columbia, Idaho, Utah, and Colorado to support reintroduction and augmentation programs using wild-trapped birds of the appropriate genetic stock.

Predator control: Predator control is rarely recommended as a tool for management of North American grouse (Hewitt et al. 2001, Schroeder and Baydack 2001). This is due to numerous factors including lack of information on the long-term consequences of predator control, the relatively high cost of predator control, the protected status of many potential predators, and concerns about public attitudes towards predator control (Messmer et al. 1999). Predator control to increase production and recruitment of sharp-tailed grouse would need to occur over broad geographic areas and target a large suite of predators to be effective. Even then, the program would need to be ongoing; otherwise, the benefits would be minimal and only last a short time. Certain predators of grouse are easier to control than others are, and many of the avian predators are protected by law and cannot be controlled. The result may be predator exchange (i.e., removing one predator may increase densities and predation rates of another predator) with no net decrease in predation rates (Parker 1984, Greenwood 1986).

The entire predator control issue is compounded because predator/prey relationships are extremely complex and difficult to study. Hoffman (2001) noted that any attempts to evaluate the success or failure of predator control will be fraught with problems. The data will most likely be inconclusive, open to broad interpretation, and will have limited application because predation patterns in one portion of the range seldom mimic patterns in another portion of the range. Predator management for sharp-tailed grouse is better addressed by protecting and manipulating habitats and reducing or modifying factors that facilitate predation (Hoffman 2001). However, if habitats for CSTG become more fragmented and altered and populations become more threatened or endangered, it may be necessary to reconsider predator control as a management tool and to evaluate its viability through experimentation (Schroeder and Baydack 2001).

Information Needs

Connelly et al. (1998) identified the following priorities for research on sharp-tailed grouse:

❖ develop effective management strategies to stabilize and ultimately increase populations that are declining or failing to expand their range

❖ improve our knowledge on the effects of hunting

- ❖ improve our understanding of the genetic relationships among individuals, populations, and metapopulations

- ❖ improve our understanding of the lek mating system of sharp-tailed grouse.

The recommendations by Connelly et al. (1998) are applicable to CSTG in Region 2.

Studies in Region 2 have provided baseline information about the status, distribution, general life history, and ecology of CSTG, but additional studies are needed to compliment this information. Many basic life history traits of CSTG in Region 2, such as seasonal food habits, chick survival and recruitment, winter habitat use patterns, and lek attendance patterns, remain poorly studied. Some of this information has been collected on other subspecies of sharp-tailed grouse and on CSTG populations outside of Region 2. It is uncertain whether this information fully pertains to CSTG in Region 2. For instance, movements, population dynamics, and habitat use patterns of CSTG in Washington, where populations are small and isolated from each other, may not be the same for the larger, more contiguous population in northwestern Colorado and south-central Wyoming. Information from studies outside of Region 2 should be interpreted and used with caution in formulating management strategies for CSTG in Region 2.

Uncertainty remains about the distribution and status of CSTG in Region 2, particularly in Wyoming. The Wyoming Game and Fish Department attempts to count CSTG leks, but efforts are not consistent from year to year, and at times, counts are late in the breeding season because surveys of greater sage-grouse take precedence. It is imperative for conservation planning purposes in Region 2 that the Wyoming Game and Fish Department make a concerted effort to count known leks and to conduct searches to locate new leks.

The presence or absence of CSTG in Mesa County, Colorado also needs to be confirmed. The last sightings were in 1985 on the north end of the Uncompahgre Plateau (Giesen 1985). Subsequent efforts to find CSTG in this area have been unsuccessful. However, the searches were conducted after the peak of breeding activities when small leks may have easily gone undetected. Additional searches should be conducted during the peak of breeding activities from mid-April to early May to be certain CSTG no longer occur in Mesa County.

Potential reintroduction sites have been identified in Colorado, and transplant programs are currently in progress. An evaluation of potential reintroduction sites has not been conducted in Wyoming. Areas that need to be searched and evaluated include portions of Uinta, Lincoln, and possibly Teton counties near the Utah (Uinta and Lincoln counties) and Idaho (Lincoln and Teton counties) borders. Remnant populations may still exist in these areas, or more likely, sharp-tailed grouse from established populations in Utah and Idaho may occasionally pioneer into extreme southwestern and western Wyoming, but in insufficient numbers to establish a population.

Before transplants are conducted in Wyoming, the genetic status of CSTG in northwestern Colorado and south-central Wyoming should be confirmed. Preliminary evidence suggests that CSTG in northwestern Colorado are genetically dissimilar from other populations of CSTG. More samples need analyzed from Colorado to confirm the preliminary findings. Since the south-central Wyoming population is contiguous with the northwest Colorado population, CSTG in south-central Wyoming may very well be genetically different from other populations. This is speculation and needs further study and confirmation. Sharp-tailed grouse captured in Idaho or Utah may prove to be a better source of transplant stock for southwestern and western Wyoming than birds from Colorado or south-central Wyoming.

Cannon and Knopf (1981) found that for lesser prairie-chickens surveyed over large areas, the number of active leks exhibited a strong positive correlation ($r = 0.94$) with density of displaying males (number per 100 ha) and only a weak correlation ($r = 0.75$) with average lek size. In essence, as populations increase, males exhibit a greater tendency to form more leks than to increase the size of existing leks. This may be happening with CSTG in northwestern Colorado. It may be that fidelity to natal areas is strong in CSTG. Rather than pioneering into unoccupied habitats during periods when populations are increasing, CSTG may form more leks. Studies are needed to better understand the lek dynamics of CSTG during periods when populations are increasing and decreasing. Documenting when, where, and how juvenile grouse become established on leks should be a major objective of these studies.

Because CSTG in Routt and Moffat counties are not expanding on their own, the CDOW has proposed transplanting grouse into areas adjacent to occupied

habitats. However, it is uncertain how far birds must be moved before they will not attempt to return to where they were captured. Attempts to collect this information must be included as part of any transplant program.

For effective conservation of CSTG, a better understanding is required of how the subspecies responds to alterations in habitat and changes in environmental conditions. To obtain this knowledge, it will be necessary to implement longer-term studies than have been conducted to date. Long-term data sets are needed to capture a suitable amount of environmental stochasticity to conduct a reliable population viability analysis. Long-term studies also are essential to better understand the factors that regulate CSTG populations. A prerequisite to this understanding is the need to develop a standardized, statistically valid technique to monitor population densities of CSTG. This information traditionally has been collected using lek counts, but no attempt has been made to understand the lek attendance patterns of CSTG. It is unknown whether all males attend leks or how consistently they attend leks. It is generally accepted that males only attend one lek, but even this has not been confirmed for CSTG. Likewise, it is assumed that all females attend leks, but since females are only captured and counted on leks, it is unknown whether this assumption is true. Another assumed characteristic of CSTG populations is that the sex ratio is essentially 1:1. This assumption is based on wing samples collected during the fall hunting season, which may not be representative of the population.

Biologists and land managers must have a comprehensive knowledge of the seasonal habitat requirements and temporal patterns of resource selection of CSTG to develop and carry out management programs effectively. Several studies in Region 2 have attempted to collect this information (Oedekoven 1985, Giesen 1987, Klott 1987, Boisvert 2002, Collins 2004), but more comparative studies are needed on how CSTG use and perform (survival, reproductive success) within and among the different habitat types they are known to use for breeding, nesting, and brood-rearing. For instance, CSTG are known to use CRP in Region 2 for lek sites (Hoffman 2001). They also have been documented nesting and raising broods in CRP in Region 2 (Boisvert 2002). However, Hoffman (2001) postulated that CSTG may perform better in some CRP fields than others depending on the composition and structure of the vegetation within the fields as noted for lesser prairie-chickens in Kansas (Fields 2004). This aspect of CSTG ecology still needs to be investigated.

Little is known about the distribution and habitat use patterns of CSTG in Region 2 during winter other than general descriptive information. More effort needs to be directed at identifying and mapping known wintering areas. Boisvert et al. (2005) recommended that additional studies are needed to ascertain why CSTG breeding in mine reclamation and CRP move long distances to use specific areas during winter when other apparently suitable areas closer to leks are by-passed. This does not appear to be the case for CSTG breeding in native shrubsteppe (Collins 2004). Additional studies of CSTG in native shrubsteppe are necessary to confirm the findings of Collins (2004).

Food habit studies have primarily focused on the adult segment of the population using techniques (e.g., fecal analysis, observations of feeding birds, and observations of sign) that may not accurately reflect diet composition. No food habits studies of CSTG have been conducted in Region 2. Studies in Colorado suggest that the brood-rearing period may be a critical time of year for CSTG using native shrubsteppe (Boisvert 2002, Collins 2004). It is unknown whether the problem is related to habitat quality, food availability, or both. Knowledge regarding the food habits of CSTG chicks from time of hatch until they start eating the same foods as adults would be helpful in addressing this issue. In addition, knowledge of the foods important to adult CSTG during spring, summer, and fall is essential for directing management efforts to restore native habitats, for developing seed mixtures for CRP plantings, and for providing recommendations to the energy industry for improving reclamation seed mixes. Additional knowledge also is required about the influence of nutrient levels and secondary compounds on food selection and whether food selection patterns differ by gender. Evidence suggests that CSTG in Region 2 are highly dependent on serviceberry for food during winter, but it is unlikely that all serviceberry plants are equally valuable as food. An understanding of the physical and chemical attributes of serviceberry that CSTG select as food is critical to protecting and managing winter habitats.

Hunting as a possible factor suppressing CSTG populations on public hunting areas will likely become a contentious issue in the future. The merits of hunting are being increasingly challenged by the non-hunting public. It is imperative that state wildlife agencies have strong biological justification for hunting any species. It is difficult for some members of the public to understand how the CDOW can continue to authorize hunting seasons on CSTG when it has been petitioned

twice for federal listing. The extent to which hunting is compensatory or additive remains debatable. Definitive experiments are needed to resolve this debate. Accordingly, there must be an ongoing effort to increase the precision of harvest estimates. Better information is needed on the distribution of the harvest so potential problem areas can be identified and regulations enacted to protect against overharvest. An effort must be made to determine if populations on public hunting areas are self-sustaining or maintained by immigration of birds produced on surrounding private lands that are unhunted or only lightly hunted.

New studies on CSTG should focus on applied research and move from descriptive, correlative, short-term work on small geographic areas, to large-scale, long-term experiments that include treatments, controls, and replications. Data derived from such studies are lacking for CSTG. Well-designed experimental studies are essential for understanding the effects of grazing, energy development, urbanization, fire, recreation and other human-related activities on CSTG populations and habitats. Ideally, these studies should be conducted in collaboration with scientists from other disciplines and with scientists working on other species of wildlife that live in association with CSTG. The recommendations resulting from these studies must be tested through well-designed experiments to evaluate their effectiveness in achieving the desired outcome (adaptive management). It is only under this scenario that recommendations can be developed for managing CSTG populations and their habitats. Recommendations developed under this scenario will have greater credibility and support among decision makers, and most importantly, a higher likelihood of being implemented than recommendations based only on descriptive studies.

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